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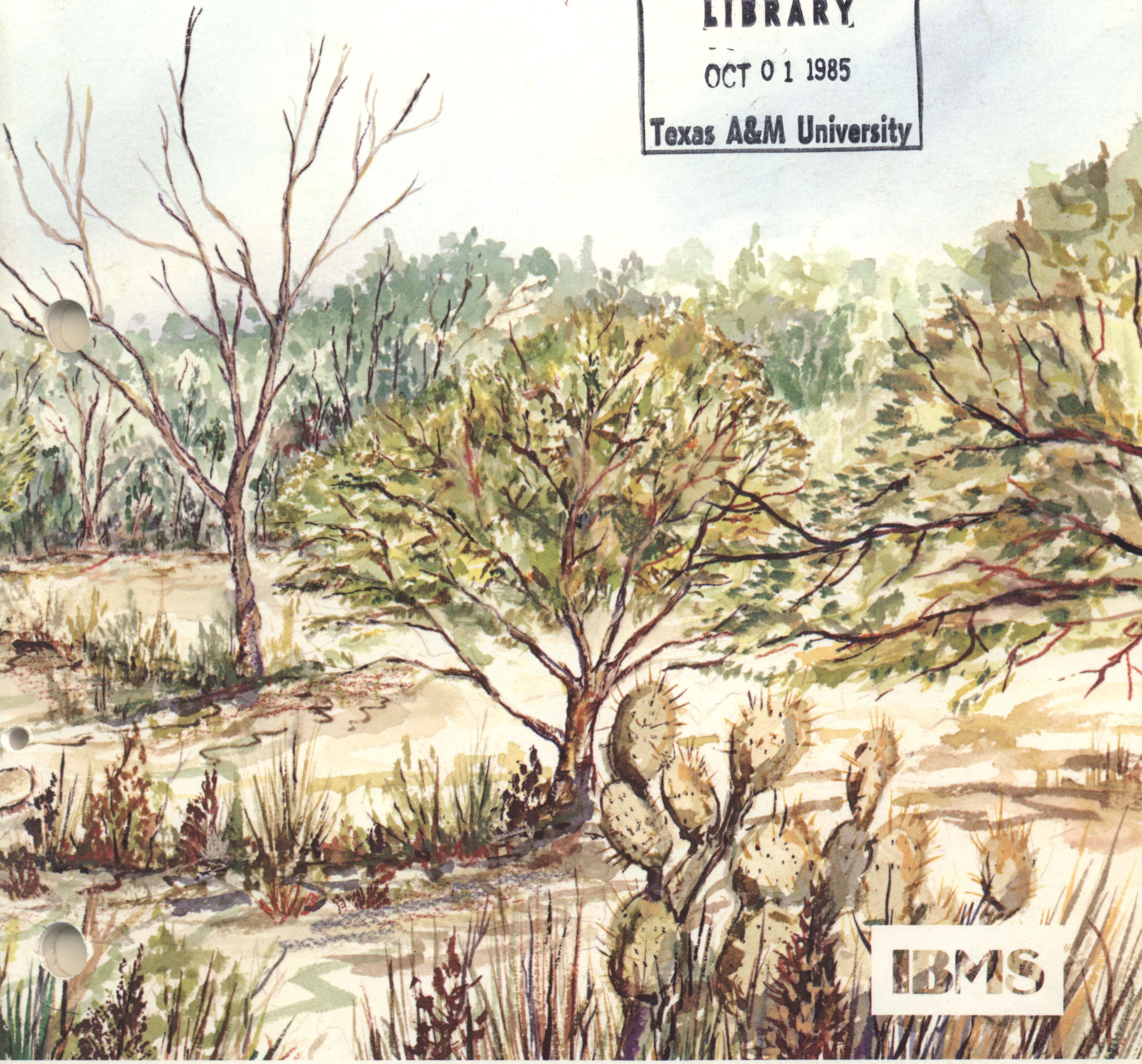
INTEGRATED BRUSH MANAGEMENT SYSTEMS for South Texas: Development and Implementation



IBMS

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INTEGRATED BRUSH MANAGEMENT SYSTEMS

for South Texas: Development and Implementation

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Foreword

Excessive cover of woody plants has been a growing problem for Texas range managers for more than a century, a problem overshadowed only by the area's scanty and erratic rainfall and fluctuating livestock prices. All other issues seem inconsequential compared to these management concerns—drought, prices, and brush. Among land managers, the term "brush" includes all woody and succulent growth forms—trees, shrubs, vines, cacti, and even subshrubs—that are deemed undesirable or of low utility for livestock production.

Significant technological advances, both in theory and method, have been made in the past 50 years toward coping with the brush problem. Most of this technology, however, has been developed by individuals working on specific control methods and, unfortunately, in relative isolation from scientists studying related resource management activities such as wildlife management and livestock grazing. Recognizing the potential of interdisciplinary teams of scientists concentrating on management problems, the Texas Agricultural Experiment Station in 1980 formed a task force of selected researchers to study range resource management in South Texas. This group is composed of scientists with special expertise in brush management, wildlife biology and management, economics, decisionmaking at the ranch firm level, and grazing management and nutrition.

Although South Texas is a unique range resource, management principles emerging from research in that area have extremely broad applicability, largely because of the extreme diversity in climate, vegetation, and soil from the near subhumid coastal zone to the semiarid western Rio Grande Plains. This bulletin relays the concepts and implementation procedures for an approach to range resource management, developed largely by the interdisciplinary research group, that uses brush control in an overall ranch management context. Because most of South Texas is privately owned, and because the area has certain attributes and management requirements that are unique, the prevailing South Texas range management doctrine does not agree entirely with that of the western United States. However, ecological principles employed by managers in South Texas adhere to basics that apply to range management worldwide.

This publication presents our perception of the critical elements for developing Intergrated Brush Management Systems (IBMS) based on experiences in South Texas. The IBMS approach essentially involves organizing information from the entire array of range resource management activities that relate to brush management. Where possible, examples illustrate the principles underlying the process. Referenced literature contains additional information on specific practices. We hope range researchers and managers in other geographical areas will benefit from applying the IBMS approach to their situations.

—*C. J. Scifres*

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1

IBMS: Ecological Basis and Evolution of Concepts

C. J. Scifres

For more than a century, excessive cover of woody plants has been a primary concern of southwestern range resource managers. Indeed, it is one of two basic ecological problems of the average South Texas range manager. Only the scarcity and erratic nature of rainfall is considered more important. The South Texas Plains are so dominated by woody plants that the region has long been referred to as the "brush country," and its rolling thorny shrublands are perceived by many as good for little more than habitat for wild animals and range for cattle raised by a persistent few. Yet, much South Texas rangeland has high production potential, as evidenced by its conversion to production of grain sorghum, cotton, peanuts, vegetables, and other crops. Likewise, the potential for increasing range-related products, especially cattle and wildlife, is great. The first step in realizing this production potential is developing a management plan that will make best use of the rangeland, and any such plan invariably must consider brush management.

Much of the information in this chapter represents a synthesis of previously published work (45,46, 48,49,52,54). It is included as a state-of-the-art background for subsequent chapters.

The Brush Problem

The most common perception of brush is "a growth of shrubs or small trees usually of a type undesirable to livestock or timber management, but which are sometimes useful or can be managed for wildlife" (46). This definition is somewhat restrictive for application to South Texas where the brush complex is composed of trees (sometimes relatively large), shrubs, subshrubs, vines, and persistent succulents. Brush stands in the area are often aggregates of 15 or more species, most characterized by thorns or spines and existing in three strata—overstory of trees, midstory of shrubs, and a lower story of subshrubs and cacti. Frequently the cover is so heavy that only shade-tolerate herbaceous plants exist and their access to livestock is precluded (Figure 1-1).

These mixed brush stands are often dominated by honey mesquite and other species including blackbrush, guajillo, huisache, twisted acacia, whitebrush, spiny hackberry, lotebush, brasil, pricklypear, wolfberry, desert yaupon, paloverde, cenizo, Texas persimmon, leatherstem, guayacan, javelinabush, Texas kidneywood, lime pricklyash, allthorn, Texas colubrina, and many others. (See Appendix A for scientific names of plants mentioned in text.) Thus, the mixed-brush stands are composed of woody plants which vary genetically, in growth form, and in susceptibility to management treatments.

Origin of the brush problem

Much of South Texas, like much rangeland in the southwestern United States, was at one time largely open grasslands with stands of woody plants occurring as isolated individuals or mottes on the uplands and heavier stands concentrated in the lowlands and waterways (3,22,26,46). However, the notion that the brush problem developed only recently, or that most of the woody plants were introduced only recently, contradicts the historical record. With rare exception, such as Macartney rose, problem plants on South Texas rangeland are natives. Some of today's species probably were present at the close of the Pleistocene (3). Archeological digs along the Frio River have yielded honey mesquite remnants dating to 1300 B.C. (19). Without question, however, there has been a drastic decrease in the amount of open prairie and savannah since the 16th century. Most ecologists agree that the present broad expanses of shrublands in South Texas are the result of

Figure 1-1. South Texas brush complex composed of trees, shrubs, subshrubs, vines, and persistent succulents.

increasing stature and density of woody plants.

After considering published opinion (3,7,22,26,29,42), limited observations based on eye-witness accounts (46), and a synthesis of our personal observations, we hypothesize that the pristine grasslands of South Texas were largely the products of fire and drought (52). Native herbivores apparently coevolved with the grasslands (54) and pre-European man apparently did little to upset their ecological balance.

Our understanding of the role of fire as a regulating influence is incomplete because we have no precise means of determining fire frequencies. However, the rolling prairies typical of much of South Texas probably were burned at 5–10-year intervals. Certain localized areas, such as those near the coast inhabited by Indians using fire to repel insects and expose food, may have burned more frequently.

We propose that these natural disturbances (the interaction among fire, drought, and grazing by native animals) created a widespread vegetation type that was held in a dynamic "steady state." This concept acknowledges short-term and (or) local variations obviously imposed by weather extremes, physical disturbances, soils, and (or) changes in pattern of grazing. The dynamic interaction of these forces existed until European man started the South Texas range livestock industry.

Man's first action was to change the kind and pattern of grazing on South Texas ranges. Cattle, sheep, goats, horses, and asses were introduced into an area formerly grazed by bison, deer, antelope, and other wild animals.[1] During dry periods the wild animal herds moved to more favorable feeding grounds giving the rangeland a natural grazing deferment. Although man initially followed animal husbandry practices, such as herding, which simulated some aspects of the grazing pattern of wild animals, certain drastic changes were introduced. For example, man's herds were not as far ranging as the wild animals. Even free ranging cattle did not move over areas as large as those used by wild animals. Also, there were obvious differences in the kinds of animals. Sheep, an extremely important influence in South Texas in the 1800's (29), were kept in great numbers. During severe drought periods, they could not always be moved out of the dry areas, usu[...] to the demise of both vegeta[...] and sheep. In addition, wild horses were numerous locally in the 1850's and wild unbranded cattle were also to be found (29).

Although some range burning was practiced by the stockmen, it decreased in popularity as the numbers of livestock increased. According to Lehmann (29), "Even in the early years of the sheep era, however, grass in the central Rio Grande Plains normally was too scanty to fuel immense conflagrations dangerous to livestock. Combustible plant material, and range fires, decreased as sheep increased. Some suggested purposeful burning as a means of increasing grass on sheep ranges. Randall, however, pointed out that fire could hardly be used to advangtage since 'sheep actually *extirpate* those of the prairie grasses which they will feed on, so that burning over could not cause *these* to resprout the same season or afterward' (emphasis mine)."

Drought has always been a [...] of the South Texas environm[...]

[1]There are some who would disagree with that general assessment of early herbivory. For instance, Lehmann (29) said, "Vegetation of the Rio Grande Plains evolved without appreciable pressure from native grazing animals. Bison were few and confined largely to territory east of San Antonio. Even in Spanish times, antelope were neither widely distributed nor generally abundant."

(29). Cabeza de Vaca encountered drought during his first trip across the area in the 1530's, the "panic of 1893" was brought about by 20 months without rain, and cattle starved in the droughts of 1886 and 1893 because of the lack of grass (29).

As a final major influence, passage of fencing laws in the 1880's resulted in most of the range being fenced by the 1890's. When the range was open, animals could be moved to local areas of rainfall. After fencing, each rancher could take advantage of rainfall only within the confines of his fences.

Thus reducing fire, introducing domestic livestock, and fencing the domestic grazers facilitated development of contemporary South Texas shrublands. Through the course of several hundred years, the woody plants increased to dominant stature, and a new steady state emerged.

Recent Assessment

Recently, we took our hypothesis one step further to suggest that the process just reviewed is not reversible because the natural frequency, intensity, and scope of the original disturbances cannot be recreated (52). Further, a total reversal would be illogical, considering man's land use needs. However, man can use improved technology, such as brush control and systematic grazing, to shift the competitive edge toward herbaceous vegetation on certain areas. Permanent conversions will not be possible, however, even with the best available technology. Seeds in the soil and from surrounding woody plant communities cause areas converted to dominance by herbs to be constantly disposed to revert to dominance by shrubs. These hypotheses form the ecological basis for our approach to development of Integrated Brush Management Systems (IBMS).

Best management of South Texas brush requires technology from a number of disciplines. Progress demands a broader base of expertise than can be offered by range scientists alone.

Although increased livestock production is usually the primary goal of range management, there are other products (notably wildlife) which for economic purposes must also be considered in range management programs. Because land management goals differ, the relative degree of emphasis on each rangeland product will obviously vary among ranches and no two brush management programs would likely be the same.

Several realities come into play in the development of range management programs (54). First, the ultimate extent of application of any technology in agricultural production is a function of its economic viability. Second, because rangeland is managed extensively, potential for economic inputs is seriously constrained, compared with agricultural systems which require intensive management but yield relatively great amounts of product per unit area. Thus, new technology is applicable to range management only if its biological effectiveness is accompanied by the necessary level of economic efficiency. Brush management, then, *is a management problem that must be approached on an ecological basis and within a closely defined economic framework.*

The IBMS Concept

The chronology of research approaches to the brush problem has been published previously (46,47, 49,52,54,57), so only a brief overview is included here.

According to pre-1950 literature, early research workers set out to develop methods to *eradicate* brush. The dictionary meaning of eradicate is "to remove or destroy utterly; extirpate; to pull up by the roots." The term found a prominent place in the vocabularies of ranchers and researchers bent on ridding the rangeland of all brush (52,57). By the early 1950's, however, even the most ardent range workers were conceding that the attitude surrounding eradication was overly optimistic, if not impossible. Exterminating entire populations of woody plants was recognized as an economic impossibility, even if it were biologically possible. Further, the concept of eradicating any plant species implies that it possesses no value.

By the middle 1950's, brush control was generally adapted as a philosophical alternative to eradication (46). Although relatively little economic research on brush control was available, the idea of controlling brush to the point of maximum economic advantage began to permeate private, professional, and technical exchanges. Yet, eradication still finds its way into the literature (especially popular releases), and the use of brush control connotes, in its purest sense, the persistent desire to kill 100 percent of the targeted woody plant stand.

General recognition among range technicians that wildlife represents a viable economic entity and that management objectives should usually incorporate improvement in wildlife habitat has promoted acceptance of the brush management approach. "The concept of *brush management,* 'management and manipulation of stands of brush to achieve specific management objectives,' fully embraces the potential values of certain quantities of woody plants in range management" (52). The term "brush management" and certain elements of the brush management concept were presented by Box and Powell (6) in 1965, but development of working bases for the approach occured only a few years ago (46). We have proposed—"Although the concept of brush management on rangeland is not new, the time appears right for vigorously promoting its general acceptance" (45).

Using brush control to best economic advantage is central to effective brush management. However, the effective lives of many standard brush control treatments fall short of the time required to pay back the investment (71). Application of low-cost secondary treatments may extend the effective lives of some brush management treatments long enough for profits to be returned. There may be several possible alternatives for application following the initial treatment, each potentially yielding a somewhat different end result (16). The best choice for a follow-up treatment often may be based on economic comparison. Such comparisons in the IBMS context require that the initial treatment and the follow-up treatments be subjected to economic analysis as if they were a single entity treatment (52).

Ultimate effectiveness of any brush managment program may hinge largely on the effectiveness of other land management procedures—grazing managment in particular, but also livestock herd management, wildlife management and merchandizing strategies, and other practices.

Thus, several land management practices must be applied simultaneously to meet a series of range management goals on the same land area. Careful planning and coordination are obviously required to achieve such goals.

Effective developement of brush management systems will require some new approaches to range research. Most important are studies which enhance responses of rangeland resources as a whole over many years rather than just brush control effectiveness of single treatments for a few years. The word "system" has many definitions, but those with greatest application to brush management include 1) a coordinated body of methods or a complex scheme of procedures, 2) any formulated, regular, or special method or plan of procedure, and 3) due method or orderly manner of arrangement or procedure.

Since the necessary management procedures must be carefully organized into a viable system (integrated), we now espouse the concept of Integr[illegible] Brush Management Systems (IB[illegible] Although research can provide technologies for use in management systems, ultimate success can be achieved only through their proper application by land managers. The keys to effectively implementing IBMS are 1) a high degree of management expertise at the ranch firm level and 2) an appreciation of the need for flexibility in selection of alternative practices during the process of implementing the system. The remaining chapters describe, in some detail procedures for developing IBMS to meet specific range management goals.

2

Initiating IBMS

W. T. Hamilton

The IBMS process provides a basis for choosing, implementing, and evaluating actions required to meet objectives for integrated range vegetation–livestock–wildlife management. As with any plan, IBMS must begin with the setting of objectives.

A basic tenet of IBMS is that the best plans are developed from a comprehensive inventory and evaluation of resource capabilities and limitations. Using this information, IBMS applies the latest technology to develop treatment alternatives. The process includes feed-back loops that provide new information or perspectives so that objectives and plans can be continually matched with projected and actual resource responses.

Objective Setting

The first step in IBMS development is to clearly identify management's objectives for the land considered in the planning process. Selection of the IBMS planning process by managers implies a willingness to implement changes. These may range from a minor revision of production emphasis, such as giving increased priority to income from wildlife, to a major conversion of land to highly intensive management, such as tame pastures or cropland.

IBMS development assumes that rangeland managed by ecological principles, as opposed to highly developed agronomic systems requiring external nutrient and energy inputs, will remain the major component of the enterprise production base. However, this does not totally exclude existing pasture or cropland, or the development of new pasture or cropland, from IBMS. For example, such areas may be included if they supply necessary forage for livestock and wildlife on associated native rangeland. Buffelgrass or other introduced pastures, small grains, or forage–hay–silage crops could all be included in grazing systems integrated with IBMS rangelands. IBMS is not a suitable planning vehicle for converting rangeland into crop production where crop production becomes the principle consideration for management of total resources.

Objective relationships

Management objectives for rangeland resources are established by the controlling interest, whether this be a sole owner, a managing partner, executors of a trust, executive elements of a corporate structure, or administrators of the public domain. IBMS requires establishment of generalized objectives and planning guidelines (premises) by such leadership to give direction to the process. For example, a generalized objective might be to develop a commercial cow–calf operation in coordination with a hunting lease enterprise. More specific objectives can then be refined as the resource inventory and evaluation are completed.

Objectives at the initial planning stage must not become so specific and rigid as to eliminate consideration of later alternatives. Adoption of a specific brush control program may eliminate consideration of more technically sound or more profitable alternatives if the decision precedes a comprehensive survey of soil and vegetation resources or projection of responses from interactions with livestock and wildlife programs. Therefore, IBMS deals best with generalized initial objectives which allow consideration of a variety of alternative treatments and treatment sequences. These alternatives compete in terms of capital expenditures, ultimate land appearance, follow-up requirements, and predicted financial performance.

IBMS does not impinge on the manager's prerogative to select a specific plan. It simply compares treatment sets as to relative performance and allows managers to consider a full spectrum of technology available to produce desired results. The manager's preference for a particular set of treatments is still the final criterion for decision making.

Establishing overall planning guidelines is also an important part of the IBMS decision maker's role. For example, after assessing managerial capabilities, capital limitations, economic environment forecasts, anticipated market share, and other factors, the enterprise manager may decide against a purebred cattle operation in favor of commercial livestock. These guidelines are essential to the IBMS process, for they will control the basic nature of all plans developed down through the organization.

With IBMS a manager can integrate various range improvement technologies to achieve a desired level of resource production. Such production may well optimize more than one resource product, rather than maximize any one. A typical example would be livestock and wildlife, where production of both might be optimized, as opposed to maximizing one at the expense of the other. The IBMS process identifies options for decisionmakers and ensures consideration of the inherent resource capabilities and limitations during the planning stage.

Objective setting process

Decisionmakers should be capable of expressing generalized, long-term objectives. Although these objectives most often include an increase in net income, they may also take other directions, such as better meeting public interests on public land. Either objective is functional in the IBMS context.

Objective setting may entail a meeting of management personnel to discuss resource uses or development that best fit the purpose of the enterprise. Such a meeting can establish overall guidelines and limits from which more specific planning can proceed. For example, the trust department of a bank may be interested in improving rangeland to maintain it as an income-producing unit without significant increase in managerial requirements. Administrators of public lands may be constrained by state or federal policies regulating changes. Private enterprises may limit changes to match their managerial capabilities or capital resources. In some instances, land owners may want to protect aesthetic aspects of the land regardless of financial considerations. Planning guidelines must identify the limits of change allowed within the IBMS planning process; however, there must still be adequate latitude to allow realistic consideration of alternative treatments.

A planning continuum

The IBMS objective-setting process feeds back to the manager information that may lead to modification of the initial objective(s) (Figure 2-1). The first of these feedback points occurs after an assessment of resource potential. Identification of capabilities and limitations of the resources or certain uses or treatment applications could become a basis for adjusting objectives. For example, soil surveys, land capability classifications, or evaluations of range sites or wildlife habitat may reveal that the resource lacks the ability to produce at levels required to meet the initial objectives.

Another feed-back point should occur after identification of feasible alternative treatment sets and projected economic comparisons. Economic analyses project the performance of each alternative with relation to the length of planning horizon, investment capital requirements, cash flow, and rate of return. Resource managers must weigh these analyses and choose the best alternative set (Figure 2-1). Any part of this additional information may logically reflect on the appropriateness of the initial objectives and provide cause for rethinking of emphasis or direction.

For example: Assume an initial objective is to earn 15% internal rate of return on investments in range improvements. Economic analyses of technically feasible alternative treatments may show that a 15% return is not feasible. The manager may lower the initial goal for rate of return, consider alternative program emphases, or revise land-use objectives to explore other alternatives. In effect, the objective-setting process uses a resource data base matched to technology and economic performance as a control function.

The final point where feedback may affect objective setting is a[fter] initiation of the IBMS plan [in] evaluation of an alternative set (or its component parts) in terms of actual accomplishment of goals (Figure 2-1). At any time after initial selection of a treatment set, new technology may emerge that could change the relative efficacy of available alternatives. A substantial change in the economic climate could also cause a change in plans.

Differences in projected versus actual performance of treatments, based on biological responses or economic variation, could cause rethinking of possible treatment sequences. For example, a treatment set with chaining as the initial treatment followed by maintenance burns may be modified to include a second mechanical practice, such as stacking, to prolong initial treatment benefits and to allow time for adequate fuel loads to develop.

Some treatment sets have not been documented by research [as] sets, only as individual practi[ces]. This could result in responses different from those initially projected in the planning process and could be a basis for adjusting treatments after evaluation of actual performance. Such evaluations provide a measure of the specific responses to each alternative and possible synergistic or additive effects. They also identify additional technology needed to improve performance of alternatives. This information is accepted by the system at the functional level where development of technical alternative sets takes place (Figure 2-1). Decisions can then be based on additional knowledge acquired from actual application of treatments. Resultant sets then flow back into economic analysis and initiate consideration of possible changes. It is logical that this information flow could also influence decisions fed back into the process as objectives.

Pervasiveness of IBMS

The IBMS process organizes [in]formation to improve a range manager's ability to make the right decisions. The central function of a manager is to make decisions, beginning with enterprise objectives and continuing down through the organizational hierarchy to result in operational plans. Enterprise objectives give direction to all other plans in the organization which, in turn, support these objectives. IBMS is an integral part of this process all the way down to dates for treatment applications, specifications for installation, and assessment of results. We assume that the right decisions at every level will emerge from the information provided by IBMS. While this helps top managers, it also requires organizational planning and implementation of plans to be as pervasive as the IBMS process. For example, a plan calling for a maintenance treatment must be implemented by the appropriate manager in order to meet preset objectives.

Resource Evaluation

Paramount to all other IBMS processes is a comprehensive inventory; this serves as the basis for evaluating the targeted resources. The inventory should include all available information on soils and topography, including range site descriptions of the U.S. Soil Conservation Service (SCS) containing relative percentage guides for potential plant communities (Appendix B). Range site descriptions make possible a determination of range condition based on a comparison of current vegetation with potential vegetation. Range condition may in turn be used to establish the recommended initial stocking levels for each site and management unit.

Identification and area measurement of range sites by management units, determination of range condition, and recommended stocking rates are used to produce a

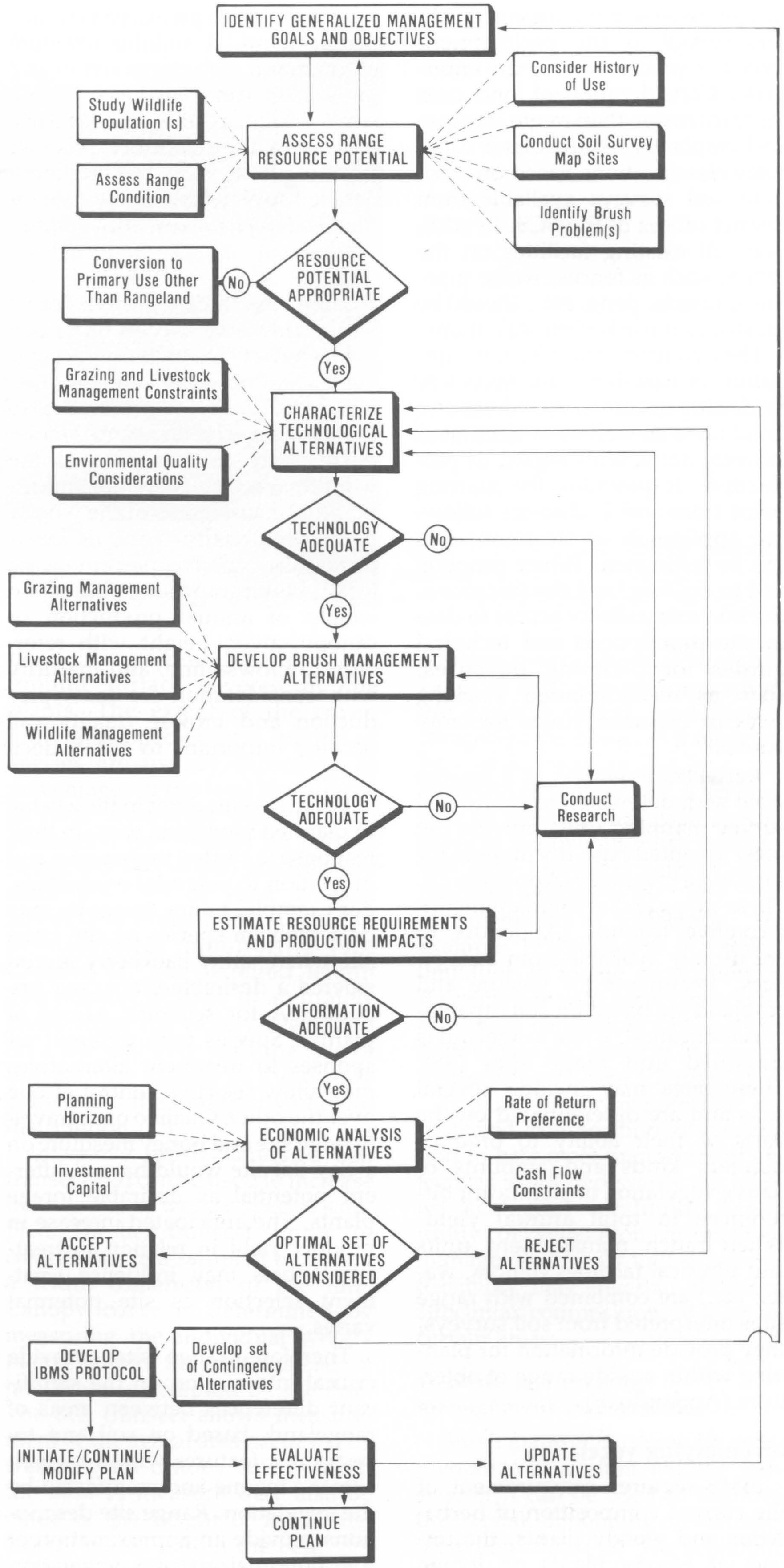


Figure 2-1. Generalized flow chart of functions and processes required for the development of an integrated brush management system.

forage inventory (Appendix C); this serves as the pretreatment record of production for the enterprise. Consideration of land uses more intensive than range (pasture and cropland) requires land capability classifications based on standard soil surveys available from district offices of the SCS. In addition, all existing facilities on the ranch, such as fences, wells, pipelines, ponds, pens, etc., should be located and marked on scale maps.

The inventory provides the foundation or base-line data necessary to identify resource capabilities and limitations as well as to document current status with regard to production. It provides the starting point from which changes following application of treatment sets can be estimated. When properly tied to existing land classifications, the inventory allows access to data in site descriptions and technical guides for planning purposes, such as recommended stocking rates or expected yields for croplands.

Aerial photographs of a known scale with delineated standard soil survey mapping units provide the most accepted base documents for a resource inventory (Appendix D). These maps and accompanying interpretive legends (Appendix E) are usually available from SCS offices. Treatments for pasture and cropland are based on soil capability classification, while rangeland is classified into range sites (38). These sites may include several soils and are differentiated on the basis of their ability to produce different kinds and amounts of native vegetation or significant differences in total annual yield. When ranch management units and physical facilities (fences, water, etc.) are combined with range sites interpreted from soil surveys, they provide information for planning within a wide range of objectives (Appendix F).

Inventorying vegetation

IBMS requires measurement of the current composition of herbaceous and woody plants, the impact of woody plants on forage production, and the relationship of woody plants to projected resource management. A suitable measure of grass and forb composition and production can usually be drawn from range condition determinations in the inventory process. Woody plants may require more detailed surveys to provide data for the IBMS focus on brush. Different woody species are preferred by different kinds of livestock and wildlife. Stature or growth forms within the same species of woody plants affect accessibility, acceptability, and nutritive value to grazing animals. Woody plants also provide cover screen and shade, particularly important to some wildlife species. Therefore, meaningful measurements of the woody plant component—such as kinds of species, relative percentage of total plant composition based on weight of annual production or canopy cover, height with reference to browse line, and maturity with consideration for mast production and browse quality—all become important to IBMS decisions.

Brush species differ in their value to planned rangeland uses, in their response to control treatments, and in relation to potential production. For example, honey mesquite may be a problem species on the same site where spiny hackberry is considered a desirable plant (see Appendix A for scientific names of plants). Species with different responses to treatment alternatives may allow selective control of one over the other. Guajillo on a gravelly ridge site and honey mesquite on a clay flat site would have a different potential as desirable forage plants. The anticipated increase in product yield in relation to treatment costs may influence treatment selection as site potential varies.

Therefore, range sites provide critical information on the significant differences between areas of rangeland, based on soil and topographic features within a given climatic regime and manifested by the vegetation. Range site descriptions provide an approximation of the potential natural vegetation among categories of plants (grasses, forbs, and woody plants) and by individual species or groups of species within each category (see sample range site description, A[illegible]pendix B). They reflect the "ste[illegible] state" or dynamic equilibrium in existence before changes that led to ecological condition degradation and release of the woody components (52) (see also Chapter 1).

By determining the current condition (as opposed to vegetation potential) of range sites, stocking rate data can be combined with projected vegetation changes to provide a basis for assessing treatment effects (Appendix C). For example, based on the SCS site description, a sandy loam site in the western portion of the South Texas Plains that is currently in "mid fair" condition would have a recommended initial stocking rate of about 22 acres per animal unit (AU) yearlong. This would represent the pretreatment production level of the site. Other measures of animal production, such as conception rates, weaning weights, daily gain, etc., must also be tied t[illegible] range production and are usu[illegible] estimated from current ra[illegible] records, experience, and observations.

Assuming that IBMS was projected to reduce woody plant density and competition on the site following treatment, a higher range production level may be projected for a specific future date. For example, it might be reasonable to assume that in year 10 after treatment the combination of initial brush management and maintenance and grazing management have allowed the range to move into "mid good" condition. The sandy loam site in good condition would have a recommended initial stocking rate of approximately 17 acres per AU yearlong, or a decrease of 5 acres required for each AU. This improvement in range carrying capacity, and any associated increase in animal performance resulting from improved forage availability and (or) nutritive value is the basis for evaluating treatment effect. It is important [illegible] recognize that the basis for co[illegible]parison (of before and after trea[illegible]

Figure 2-2. A brush survey generates information on the woody plant component for brush management planning.

ment production) is tied to the original resource inventory and subsequent monitoring (see Figure 7-2, Chapter 7).

Even if artificial revegetation is used instead of natural succession to increase range forage production, potential yields will vary by range sites and can be estimated with the use of range site descriptions (Appendix B). Differences among range sites are important in developing anticipated responses to treatments; they provide a basis for assessing benefits versus costs.

Survey methods

A resource inventory should give IBMS planners an accurate picture of the composition of total vegetation and the influence of woody plants. There are several acceptable methods for surveying woody plants; each may differ in suitability, depending on woody plant density and growth forms, the degree of accuracy desired, and the time available. All surveys, however, should be accomplished by range sites.

The line interception technique is used frequently. In this method the woody plant canopy intercepting an evaluation line is measured by species (9). Woody plant intercepts along the line are totaled to derive the percentage of the total ground surface covered by the plants. The extent of the cover, individual species, and groups of species are usually expressed as percentages of the total line which, in turn, represents the site. The evaluation line should be permanently marked so that precisely the same line can be read at each subsequent evaluation date during posttreatment monitoring (see Chapter 8). The required length and number of lines to accurately characterize the woody vegetation on a site will vary with the size of the site, the density of the woody plants, and the uniformity of plant distribution.

In sparse brush stands, a belt transect (39) can be used to increase the number of woody species sampled. The belt transect simply increases the area sampled by giving a width dimension to the line. Canopy cover is determined by measuring the individual woody plants within the belt instead of just those intercepted by the line. The belt transect allows measurement of the actual area occupied by woody plant canopy cover within the belt. A measure may also be made of the height of individual woody plants within the belt.

These survey techniques yield information on the density of brush (canopy cover), the relative significance of each species (proportionate canopy cover), and stature (height) of the plants as it relates to browse accessibility and treatment alternatives (Figure 2-2). This measure of the role that each species plays in the overall brush problem will help managers select control practices to achieve the "best mix" of posttreatment vegetation. For example, if whitebrush is a severe limitation to forage production on the same site with honey mesquite, a practice controlling one but not both would not result in maximum forage released (see Chapter 3).

It is important to note that the preferred composition of vegetation to best meet management objectives is not necessarily the highest ecological condition. Actual utility of vegetation in meeting management goals and economic feasibility may together dictate a subclimax composition, at least on certain areas.

Wildlife and grazing management assessments

Brush manipulation can be detrimental to important wildlife species, or it can be used to improve the habitat, depending on management objectives (46). The economic importance of wildlife usually dictates management concern for maintenance or improvement of game species habitat. Assessments of current and projected wildlife populations are needed by IBMS planners to evaluate the influence of brush management on habitat and subsequent wildlife quantity and quality.

Using whitetailed deer as an example, an accurate inventory of current population (density, sex ratio, reproduction efficiency, age class distribution of bucks, individual quality parameters, etc.) is needed in order to design treatment applications to meet habitat objectives and for measuring predicted responses (8). Surveys are usually accomplished by wildlife biologists, either private consultants or state personnel, working with cooperating ranches. They may include one or more methods where deer are being censused, such as fixed-wing or helicopter surveys, cruise methods (driving or walking a line by day or at night with a spotlight), or pellet group counts.

The resource inventory should also include existing physical facilities and their relationship to proposed changes in grazing management strategies (see Chapter 6). For example, watering facilities that are currently adequate in individual pastures stocked year-round may be inadequate if placed in a one-herd:multiple-pasture system. Adequacy of existing fencing to accommodate grazing system or wildlife management designs, as well as to provide required deferments associated with treatments, is also a part of resource evaluation.

In summary, an IBMS resource inventory should provide the necessary information to decid[e] brush control is needed, wher[e] should be applied, and the species that should be targeted. It must also become the basis for planning concomitant grazing management, wildlife management, and other integrated system elements. The resource inventory is the basis for projecting the biological responses from treatments and the resulting vegetation composition over time after treatment. Moreover, it becomes the means to predict maintenance needs and timing and allows planners to anticipate future vegetation composition shifts before they occur.

3

Brush Management Technologies

T. G. Welch, R. P. Smith, and G. A. Rasmussen

Selection of brush management technologies may be considered after objectives for the management units targeted for IBMS have been determined and the current and potential status of the resource thoroughly evaluated. This chapter briefly describes available mechanical, chemical, prescribed burning, and biological brush management methods. Detailed discussions of brush management methods may be obtained from Vallentine (64), Scifres (46) and other sources.

Each brush control method has applications for which it is effective and limitations which prevent complete effectiveness (46). Therefore, before selecting treatments for inclusion in an Integrated Brush Management System, the resource manager should evaluate each technological alternative relative to 1) biological effectiveness, 2) characteristic weaknesses, 3) expected treatment life, 4) secondary effects, 5) application requirements, and 6) effect on wildlife habitat (46,47,49,52).

Mechanical Methods

Equipment used for mechanical brush management is designed to remove only the top growth or the entire plant (46). Methods that remove only top growth generally provide only short-term woody plant control, whereas methods that effectively remove the entire plant provide longer term control (Table 3-1).

Shredding

Shredding uniformly removes brush top growth but rarely kills woody plants, especially those capable of sprouting from roots or stem bases. Drag-type shredders (Figure 3-1) are most efficient on plants with stem basal diameters of less than 2.5 inches, but heavy-duty, hydraulically operated shredders may remove woody plants with trunk diameters of 4 inches or more (46).

Woody plants may regrow rapidly following shredding. For example, honey mesquite, lotebush, twisted acacia, and whitebrush (see Appendix A for scientific names of plants) replace 50 percent of their original heights during the first growing season after shredding, and several other woody species replace 50 percent of their height during the second growing season (18). Repeated shredding generally causes numbers of stems

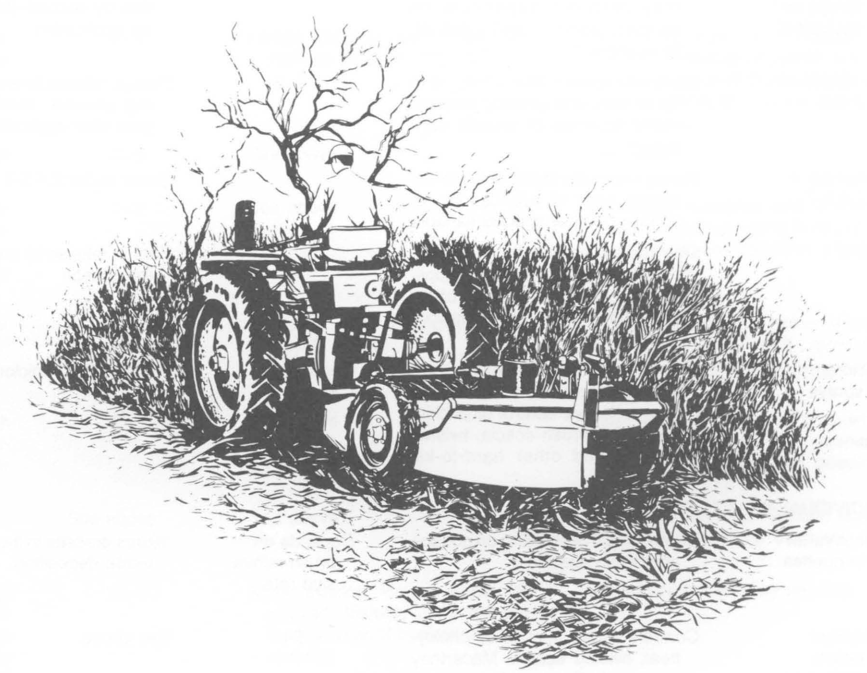


Figure 3-1. Drag-type shredder for removing top growth of brush plants with stems less than 2.5 inches in diameter.

and size of the bud zone (basal stems) to increase. Plants that have been shredded repeatedly are more difficult to control with herbicides, and may require more energy to remove by grubbing, than plants that have not been shredded. Shredding may increase the plant densities of Macartney rose and pricklypear, because fragments of rose canes or pricklypear pads scattered over the soil surface may take root. Spreading of such species can be minimized by shredding during hot, dry periods.

Although shredding will provide only short-term control of most undesirable plants, the time may be sufficient to allow grass growth that will provide fine fuel for prescribed burning. Also, shredding before application of picloram pellets (see Appendix G for chemical names of herbicides mentioned in text) has been necessary for control of spiny aster (37). Shredding may increase browse availability and quality by increasing the number of young, succulent sprouts. Shredding also improves livestock management efficiency by increasing visibility for the manager.

Roller chopping

Roller choppers are drums with several blades running parallel to the axis of the roller (Figure 3-2). The drums vary in size, and some types may be filled with water to increase their weight. Roller choppers are more durable than shredders and can be used on larger brush and on rougher topography.

Roller chopping, like shredding, kills few plants. Forage response and treatment life are similar to those described for shredding (36). Likewise, roller chopping of Macartney rose and pricklypear may result in a significant increase in plant density as cane and pad fragments take root.

Chopper blades may penetrate the soil surface from 6-10 inches deep. Thus, soil disturbance may be significant, resulting in improved water infiltration. Seeded grass stands have been established on seedbeds prepared by offset, tandem roller choppers. Prescribed

TABLE 3-1. Summary of expected responses of rangeland vegetation to selected brush management treatments and special considerations for their use in brush management systems (see text and Chapter 4)

Treatment	Expected brush response	Treatment life (yr)	Forage response	Special considerations
BROADCAST HERBICIDE APPLICATION				
Tebuthiuron pellets	Effective control of some species (eg. oaks, whitebrush); little control of honey mesquite, Texas persimmon, pricklypear, lime pricklyash and others	10+ (Greatly dependent on abundance of tolerant species)	Maximum release by second-third growing season, highly dependent on ratio of tolerant to susceptible species	Decision should be based on soil texture and brush stand composition (see also 2,4,5-T + picloram)
2,4,5-T + picloram sprays or equivalent	Good to excellent topkill season of application; 50% or more plants may resprout depending on species, season, and initial effectiveness	5–7	Forage release by end of first growing season; maximum production by second–third season after application	Alternative treatment for tolerant species should be considered at outset of planning
Picloram + 2,4-D	Generally topkills Macartney rose for at least one growing season; many species of weeds controlled	2–3	Forage release by end of first growing season; maximum during year after application	Provides only short-term control unless followed by subsequent treatment(s)
Dicamba + 2,4,5-T	Honey mesquite topkill good to excellent year of application; response of other species variable	5	Same as for 2,4,5-T + picloram	Same as for 2,4,5-T + picloram
2,4-D	May reduce topgrowth of Macartney rose by >80% year of application; little control of other brush species; some weeds controlled	1	Forage release by end of first growing season	Repeated treatment required for sustained improvement or follow with prescribed burning.
Picloram sprays	Somewhat more effective than 2, 4-D mixture on Macartney rose; effective control of pricklypear, blackbrush acacia, twisted acacia, and other hard-to-kill species	Depends on species	See 2,4,5-T + picloram	See 2,4,5-T + picloram
INDIVIDUAL-PLANT TREATMENTS				
Tebuthiuron briquettes	Complete kill depending on dosage and brush species	Depends on brush reinvasion rate	Injures grasses in local area of herbicide deposition	Primarily as maintenance treatment after broadcast treatment; or for scattered stands of woody plants
Picloram pellets (10% a.i.)	Controls small huisache, pricklypear, twisted acacia, Macartney rose, and other woody plants	5+	See above	See above; may be especially useful for spot treatment following prescribed burning
Hexazinone liquid	Controls acacias, hackberries, oaks, junipers, and mesquite on sandy-sandy clay loams	5+	Kills grasses in local area of herbicide deposition	See tebuthiuron briquettes

burning may be used to suppress brush regrowth in such stands. Roller chopping may also be used as a low-cost seedbed preparation following rootplowing (69).

Power grubbing

Power grubbing is generally used as a maintenance practice (Figure 3-3). It is effective on nonsprouting species and species that sprout from the stem base, provided they are uprooted below the lowermost bud. Power grubbing is most useful with scattered plants that are large enough (at least 3 feet tall) to be seen easily by the equipment operator (15). The size of plant that can be effectively grubbed depends on the size of tractor used.

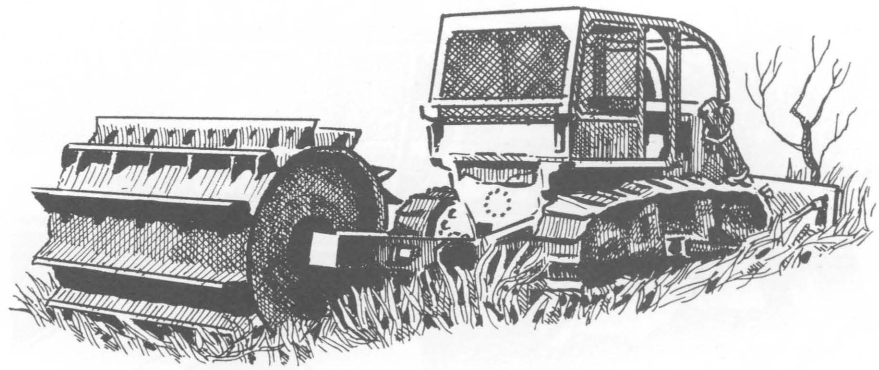


Figure 3-2. Roller chopper for removing top growth of brush plants.

TABLE 3-1. Continued

Treatment	Expected brush response	Treatment life (yr)	Forage response	Special considerations
INDIVIDUAL-PLANT TREATMENTS				
2,4,5-T	Controls most species except junipers and lime pricklyash	5+	May temporarily injure grasses in immediate area of woody plant, depending on rate and carrier	See tebuthiuron briquettes
Grubbing	Control basal sprouters if grubbed to first root; less effective on root sprouters	10+	Pits remove grass cover but trap water	Most effective for light to moderate stands of single-stemmed plants
BROADCAST MECHANICAL METHODS				
Chaining one-way	Effectively controls most plants which are uprooted, but many plants may be left rooted	2–3	Forage released year of treatment, declines as brush regrows.	Soil water must be adequate to allow uprooting of plants; chain may ride over or break off tops of small plants; pricklypear may be increased
Chaining two-ways	Generally uproots more plants than one-way chaining	4–5	See above	See above
Raking + stacking	Generally a follow-up to other treatments; some uprooting and removal of small brush and pricklypear; sometimes used for top removal of Macartney rose	1–2	See above	Effectively removes and consolidates debris resulting from previous treatment; localizes pricklypear pads
Stacking	Effective for removal of pricklypear	>5 depending on reinvasion rate	Released year of pricklypear removal	May be used to thin heavy stands of pricklypear; also removes small to medium-sized woody plants
Roller chopping	Most plants regrow rapidly; growth form changed from single to multi-stemmed form; pricklypear cover increased	2–3	See above	Can use on larger brush than with most shredders; may prepare adequate seedbed for seeding grasses
Shredding	See above	See above	See above	Generally cannot be applied when most plants basal diameter >4 inches
Rootplowing	Highly effective in killing most species if done properly. Not effective on some plants which can root from severed or broken plant parts such as pricklypear	10–20	Most existing forage plants destroyed. Majority of forage production year of treatment is from annuals	Should be followed by seeding
Offset disc	Effective on smaller, shallow-rooted brush species such as whitebrush	10	See above	See above

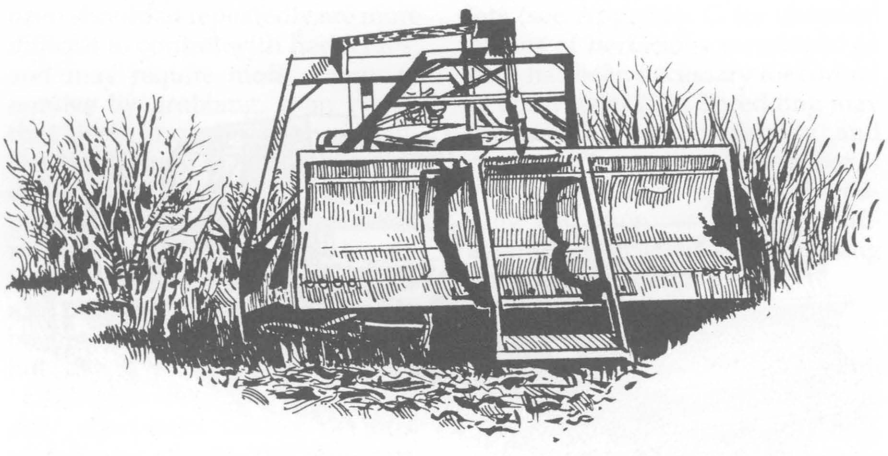


Figure 3-3. Power grubber for cutting roots 4–14 inches beneath the soil surface.

Soil texture and water content affect grubbing efficiency. The efficiency of power grubbing decreases as soil clay content increases and water content decreases (4,46). On dry clay soils, many plants may be cut off by the grubber blade, leaving part of the bud zone in the soil. Likewise, grubbing on deep sands may not be successful because accumulation of soil around plant bases increases the depth requirement for effective grubbing (46). Grubbing in shallow, rocky soils is usually not highly effective and may leave the soil surface extremely rough.

Various types of low-energy power grubbers have been developed in recent years (32,66,67). These grubbers are used on small crawler tractors and row crop tractors (Figure 3-4). Low-energy grubbers may be used to control thin stands of small brush plants. These grubbers are not recommended for plants with root diameters greater than 4 inches (67).

Pits are left in soil surfaces where brush plants are removed by grubbing. Runoff water will accumulate in these pits allowing the water to infiltrate into the soil. However, the soil surface may be left extremely rough if high densities of brush are grubbed (53).

Rootplowing

Rootplowing is a nonselective treatment used to sever woody plants in moderate to dense stands of brush. A rootplow is a V-shaped blade, 10–16 feet long with riser fins perpendicular to the blade (Figure 3-5). It is pulled behind a crawler tractor with the blade about 8–15 inches below the soil surface.

Rootplowing will control most brush species. It is least effective on shallow rooted species such as whitebrush and cacti, and ground cover of pricklypear and tasajillo may increase dramatically following rootplowing. In addition to controlling brush, disturbing the soil surface and underlying impermeable zones by rootplowing increases the water infiltration rate into some soils (46).

Although rootplowing is a highly effective brush control method, it causes considerable soil disturbance and destroys most perennial grasses. Thus, seeding is often necessary as a follow-up treatment. If a rootplowed area is not seeded, the majority of forage production for the first several years may be from annual and other plants low on the successional scale. The flush of forbs on rootplowed areas may drastically improve wildlife forage source until perennial grasses become dominant. Therefore, carrying capacity for cattle will be reduced until higher successional grasses become established (36). The soil disturbance and reduction of competition on rootplowed areas may stimulate the germination of some brush species such as huisache.

Rootplowing is costly, but the effective life of the practice may be 20 years or longer. Effectiveness of rootplowing is generally reduced on shallow rocky soils and deep clay soils. Rootplowing is best suited for deep friable, fertile soils where revegetation is feasible (46).

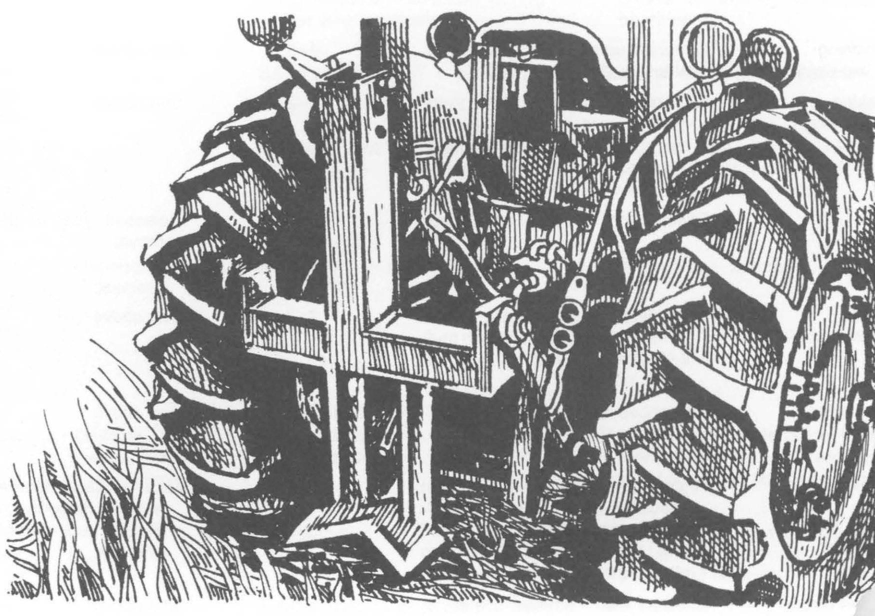


Figure 3-4. Low-energy power grubber for use on row crop tractors.

Heavy offset disk

Heavy offset disks may effectively control small, shallow-rooted brush species such as whitebrush. Because of the limited soil depth reached by the offset disk, it is generally ineffective on plants with deep bud tissues such as honey mesquite. Disking is not well adapted to rocky soils (64). Also, disking just before or immediately after rain is less effective because many plowed plants may reestablish root systems. Because of the extreme soil disturbance and potential for damage to existing perennial vegetation, disking may be most applicable to deep soils which can be seeded.

Chaining

Chaining may be used to knock down and thin moderate to thick stands of brush (Figure 3-6). Chaining alone usually gives only temporary control. It is most effective on trees 4–18 inches in diameter and a density of no more than 400 plants per acre (46). Small "switchy" brush will bend under the chain or break off above the soil surface. To obtain maximum control, soil water content must be sufficient for plant crowns and (or) lateral roots to be pulled completely out of the soil. Chaining under these optimum conditions, however, may increase the cover of pricklypear (2,13). Two-way chaining, covering the area twice in opposite directions, usually gives better control than one-way chaining. Chaining can be used on rough, rocky terrain with only moderate soil disturbance.

The percentage of brush plants actually killed by chaining is often low, and regrowth may be rapid (18). However, herbaceous production may increase the year of treatment, given average or greater rainfall (2), and may provide adequate fine fuel for prescribed burning to remove debris and suppress brush regrowth. Raking and stacking may be necessary to remove woody debris after chaining areas of heavy brush cover to allow maximum development and utilization of range forages and to minimize livestock handling problems (55).

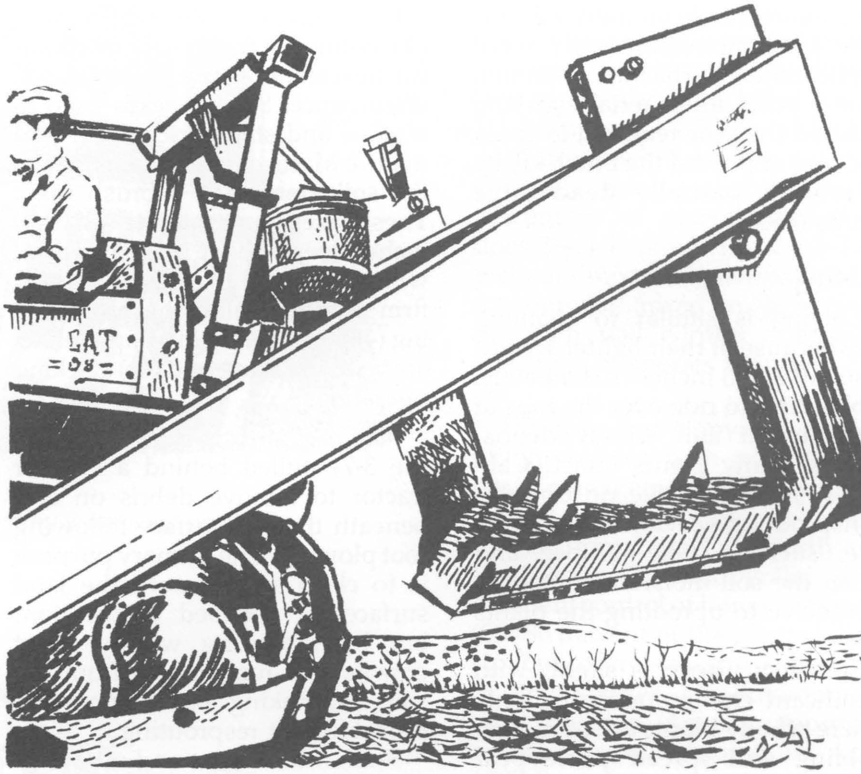


Figure 3-5. Rootplow for cutting roots 8–15 inches beneath the soil surface.

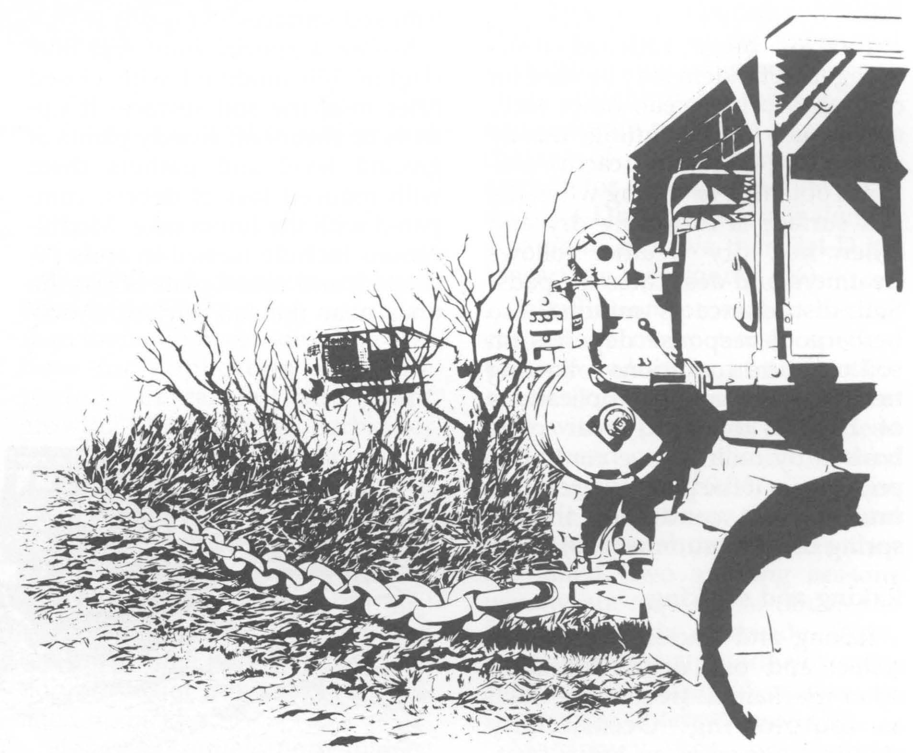


Figure 3-6. Heavy anchor chain pulled between two crawler tractors for knocking down trees 4–18 inches in diameter.

Chaining has been used successfully in combination with aerial application of herbicides. Chaining 2 or 3 years after aerial spraying reduced the time required to chain and also improved the brush kill by uprooting partially dead large plants (35,46).

Cabling

Cabling is similar to chaining but, because of their lighter weight (usually 2.5–3 inches in diameter), cables tend to ride over the tops of small brush and woody debris, leaving many plants intact. Cabling is most effective on upright, nonsprouting species of moderate size, such as ashe juniper, and when the soil moisture content is conducive to uprooting the plants (46).

Soil disturbance is slight, with significant change occurring only where woody plants are uprooted. Cabling will spread pricklypear when conducted under conditions optimum for woody plant removal. However, cabling during dry periods has been used to control cholla.

Railing

Two or more railroad irons dragged in tandem may be used for control of pricklypear, other cacti, and small nonsprouting woody plants (46). Maximum cactus control is obtained by railing when the soil surface is extremely dry and when hot, dry weather follows treatment and dessicates the pads. Soil disturbance is minimal, so herbaceous response depends on soil moisture conditions following treatment. Broadcast applications of 2,4,5-T to pricklypear pads bruised by railing have controlled pricklypear if the plants were railed under moist conditions in late spring or early summer (20).

Raking and stacking

Raking and stacking is used to collect and pile debris left from other mechanical treatments, such as rootplowing. Occasionally stacking is used as an initial treatment for control of pricklypear and for removal of the top growth of mature, dense Macartney rose (46).

Brush rakes used to collect and pile debris left from other mechanical treatments cause minimal soil disturbance. Stacker rakes used to remove and stack pricklypear and mature Macartney rose will disturb the soil more than a brush rake. These rakes penetrate the soil 6–10 inches deep and are used to control whitebrush and to prepare a clean, firm seedbed following rootplowing (46). The following implements are used in raking and (or) stacking operations:

Root rake, a drag-type rake (Figure 3-7) pulled behind a crawler tractor to remove debris on and beneath the soil surface following root plowing. The primary purpose is to clean and smooth the land surface for seedbed preparation, but by removing woody plant crowns and root tissues from the soil, root raking also reduces the probability of resprouting.

Brush rake, a front-end rake (Figure 3-8) pushed by a crawler tractor to pile debris left by a previous practice. Brush rakes have open tines which gather debris without major accumulations of soil. They may be used on either disturbed or firm soil surfaces.

Stacker, a special front-end rake (Figure 3-9) modified with closed tines near the soil surface. It uproots or shears off woody plants at ground level and gathers them with reduced loss of debris, compared with the brush rake. Modifications include turned-in ends (V-shaped) and a steel plate across the tines near the soil surface. Additional surface area may be added to the bottom tines as pads to support the stacker's weight and hold it in the correct position with relation the soil surface. The impleme works on a firm soil surface and is especially effective for removal of pricklypear.

Chemical Methods

Herbicides used on rangeland may be formulated as liquids or pellets and applied broadcast or to individual plants. These herbicides include 2,4,5-T, 2,4,5-T in combination with picloram or dicamba (usually a 1:1 mixture), picloram, tebuthiuron, hexazinone, 2,4-D, and 2,4-D + picloram combined in various ratios. Degree of brush control with herbicides depends largely on species susceptibility, rate of application, and method of treatment (Tables 3-1, 3-2). Specific recommendations should be obtained for each problem situation (8). The following descriptions are intended as general information only.

Broadcast application

Liquid herbicides are usually applied aerially in 2–5 gallons per acre of an oil:water carrier (Figure 3-10). When applied with ground equipment, the herbicide-carrier volume is 10–30 gallons per acre. Tebuthiuron pellets containing 10, 20, or 40 percent active ingredient by weight are available for aerial application only, with applicators approved by the herbicide manufacturer. Picloram pellets with 10 percent active

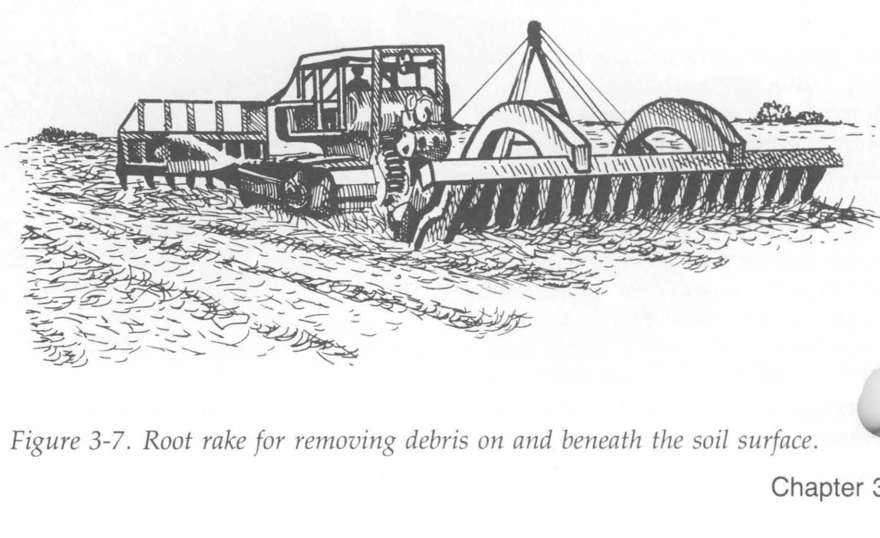


Figure 3-7. Root rake for removing debris on and beneath the soil surface.

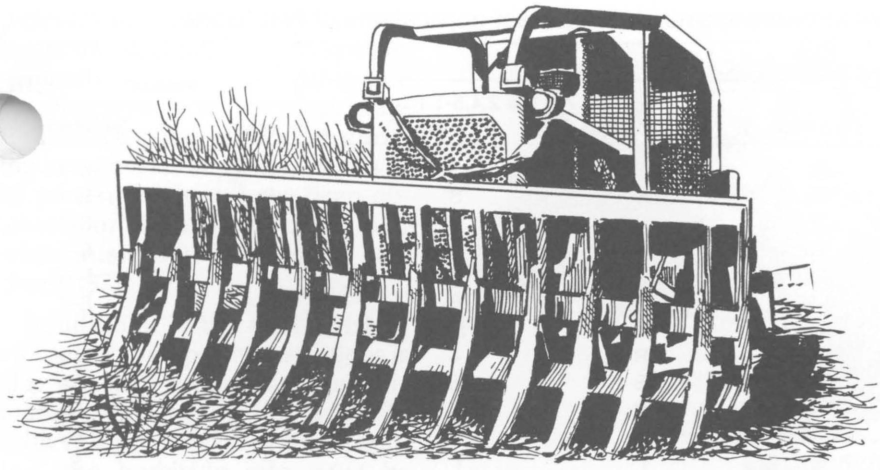


Figure 3-8. Brush rake for piling debris left by a previous practice.

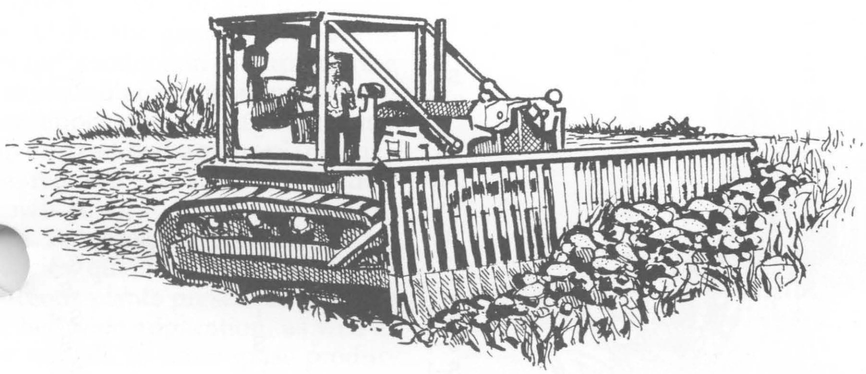


Figure 3-9. Stacker for uprooting or shearing off woody plants at ground line and gathering debris with minimum loss.

ingredient may be applied by aircraft or ground equipment.

For best results, liquid herbicides must be applied when growing conditions optimize herbicide absorption by the plant. Foliar-active herbicides usually should be applied to honey mesquite 40–90 days after bud break in the spring (17). Macartney rose, blackbrush acacia, and huisache may be sprayed during spring or fall. Generally, best results are obtained when growth conditions allow development of full foliage and the plants are not water stressed. Constraints dictated by climate and growth conditions often limit the use and effectiveness of liquid herbicides.

Conditions for application of pelleted herbicides are less restrictive than for liquid herbicides. The best time for application is before periods of rainfall and plant growth. Movement of herbicides into the soil by rainfall followed by a period of active plant growth allows maximum root uptake and translocation of the toxicant by the plants. Thus, applications in fall or late winter–early spring are most common. Low drift potential and the broad time period for application are major advantages of pelleted herbicides.

Honey mesquite canopy may be reduced by 90 percent or more during the season of 2,4,5-T application; however, based on the long-term average in Texas (46), 75 percent or more of the treated plants will resprout. Usually 40–50 percent of the plants are killed with a 1:1 mixture of 2,4,5-T + picloram. A 1:1 mixture of 2,4,5-T + dicamba generally gives a slightly greater percentage of plants killed than does 2,4,5-T alone. The 2,4,5-T + picloram mixture is normally used for control of mixed brush, because picloram will control a broader spectrum of species than will 2,4,5-T.

Triclopyr and clopyralid are liquid herbicides with potential for brush management. Triclopyr gives control of honey mesquite similar to that from 2,4,5-T in North and West Texas (24). Clopyralid gives excellent control of honey mesquite (50–80 percent of the plants killed) (25) but controls a narrow spectrum of other species. The Environmental Protection Agency approved registration of triclopyr in April 1985 for use on rangeland. A formulated, 1:1 mixture of clopyralid and picloram probably will be labeled and sold.

Temporary reduction of Macartney rose canopy may be obtained with broadcast applications of 2,4-D (21,31); however, several annual applications are often necessary to maintain control. Mixtures of 2,4-D and picloram provide a higher percentage of canopy reduction and control for a longer period than does 2,4-D alone. Picloram alone is also more effective than 2,4-D for Macartney rose control (46).

Tebuthiuron provides effective control of many brush species. Canopy reduction of susceptible species may average 80–100 percent, with 80 percent of plants dead by the end of the second or third growing season (50,56). Since susceptible species may defoliate and refoliate several times before they are killed, two growing seasons usually are required to obtain the full effect of the herbicide. Oaks, elms, whitebrush, tarbush, creosotebush, and certain acacias are susceptible to tebuthiuron (59).

Macartney rose, pricklypear, redberry juniper, huisache, whitebrush, sumac, willow baccharis, and hawthornes are susceptible to

TABLE 3-2. Relative susceptibility of certain brush species to broadcast applications of herbicides

	Foliar sprays				Pellets	
	2,4,5-T	Dicamba	Picloram	2,4,5-T + Picloram	Picloram	Tebuthiuron
Acacia, blackbrush	R	R	S	S	S	S–I
Acacia, catclaw	R	R	S	S	S	S–I
Acacia, twisted	R	R	S	S	S	S–I
Agarito	R	R	R	R	S	S–I
Allthorn	R	R	I*	I*	I*	I–R
Baccharis, willow	I–R	I–R	S	S	S	S–I
Beautyberry, American	R	R	S	S*	S	I
Buckbrush	I–R	I–R	R	--	--	S–I
Cactus, cholla	S	--	S	S	S	R
Cactus, pricklypear	I	I–R	S	S	S	R
Cactus, tasajillo	I	I–R	S	S	S	R
Cenizo	R	R	I*	I*	I*	S
Colubrina, Texas	R	R	S–I	S–I	S	I
Condalia, bluewood	R	R	I*	S–I	--	S–I
Condalia, lotebush	R	I–R	I–R	I–R	S	S–I
Creosote bush	I–R	S–I	S–I	--	S	S
Elm, winged	I	I–R	S	I*	S	S
Greenbrier	I–R	R	I–R	R	--	I–R
Guajillo	I–R*	I–R*	S	S	S	S–I
Guayacan	R	R	R	R*	--	S–I
Hackberry, netleaf	S–I	I	S–I	S	S	S
Hackberry, spiny	R	R	S–I	S–I	S	S–I
Honey locust	S	S–I	S	I–S*	--	I
Huisache	R	I	S	S	S	I
Javelina brush	R	R	R	R	R*	I–R
Juniper, ashe	R	R	S	I–R*	S	--
Juniper, redberry	R	R	S	I*	S	S–I
Leatherstem	R	R	S*	I*	--	I–R
Mesquite	S	S	S	S	R	S–I
Mimosa, catclaw	R	R	--	--	S	S
Oak, blackjack	S–I	I–R	I	S–I	I	S–I
Oak, live	I–R	R	S–I	S–I	S	S
Oak, post	S–I	S–I	I	S–I	S–I	S–I
Oak, sand shinnery	S–I	I	S–I	S–I	S–I	S
Oak, water	I–R	--	S*	S–I*	S–I	S
Persimmon, eastern	I–R	S–I	S–I	S–I	S	I–R
Persimmon, Texas	R	R	I	I–R*	S–I	I–R
Pricklyash, lime	R	R	R	I–R*	R	I–R
Macartney rose	I	S–I	S	I–S*	S	S–I
Saltcedar	S–I	S	--	S–I	S	--
Sumac	S	S	S	--	S	S–I
Tarbush	S–I	I	--	--	S–I	S
Whitebrush	R	I	S	I–S*	S	S
Wolfberry, berlandier	R	R	R	R*	I–R*	S
Yaupon	I–R	R	S–I	I–S*	S	S–I

Letter designations: S = susceptible, S–I = susceptible to intermediate, I = intermediate, I–R = intermediate to resistant, R = resistant.

Control ratings, except for tebuthiuron, are from Bovey (5) and are as follows:

S—One application of the herbicide kills more than 70 percent of the stand.

S–I—Two applications of the herbicide are needed to kill at least 70 percent of the stand.

I—Top-killed by one or two treatments, but several more treatments are usually required to kill plants.

I–R—Tops and sprouts can be killed but roots continue to sprout even after repeated applications.

R—Species virtually unaffected by herbicides.

Control ratings for tebuthiuron are from Scifres (50) and are as follows:

S—Controlled by 0.5–2.0 lb ai/a.

S–I—Controlled by 2.0–3.0 lb ai/a except on heavy clay soils.

I—Controlled by 3.0–4.0 lb ai/a except on heavy clay soils.

I–R—Controlled or partially controlled by rates greater than 4.0 lb ai/a.

R—Not controlled by 4 lb ai/a.

*Personal communication with C. J. Scifres.

picloram pellets. The effect of picloram on susceptible brush species generally is manifested within one growing season, except on pricklypear which usually takes two growing seasons. Canopy reductions of 80 percent or more have been obtained on Macartney rose (44), whitebrush (51), and willow baccharis (37).

In addition to the factors listed, efficacy of soil-applied herbicides is also affected by clay and organic matter content of the soil. To achieve a given level of brush control, the herbicide rate must be increased as clay and (or) organic matter content increases.

Forage production may increase significantly during the first growing season after a liquid herbicide is applied. When pelleted herbicides are used, the greatest increase in forage production occurs during the second growing season following application. Abundance and diversity of herbaceous plants may be reduced by some herbicides, however. Of course, degree of forage response is influenced by species, quantity, and vigor of herbaceous plants present at the time of herbicide application, as well as by rainfall. In time, grass production generally declines as woody plants reestablish and canopies are replaced. Within 5–7 years after application of liquid herbicides, grass production may have retreated to pretreatment levels.

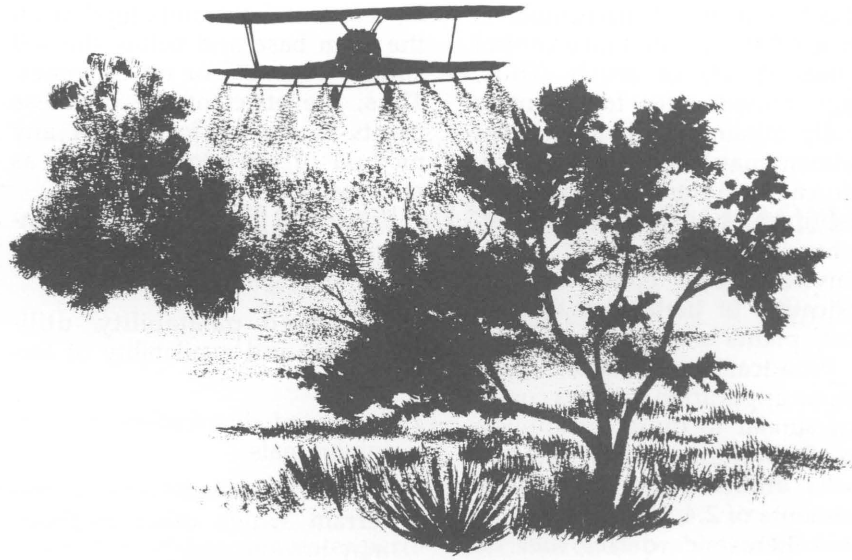


Figure 3-10. Aerial herbicide application for brush control.

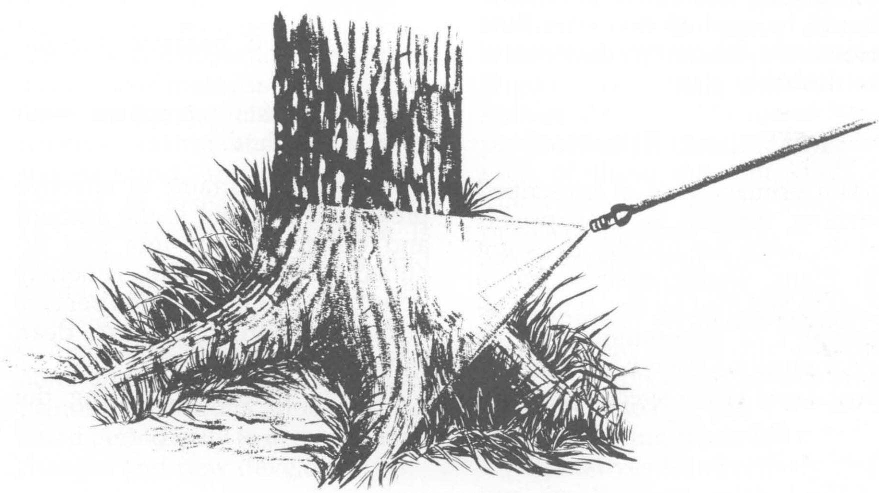


Figure 3-11. Stem base herbicide application for maintenance control.

Individual-plant treatment

Herbicides used for broadcast application may also be used for treatment of individual plants. Tebuthiuron is formulated as a briquette, about the size of a thumbnail, that contains 250 milligrams active ingredient. The liquid formulation of hexazinone (2 pounds active ingredient per gallon) is labeled for individual-plant treatment using a spot gun. Liquid formulations of picloram, 2,4-D, and dicamba are generally used as foliar treatments, whereas 2,4,5-T is used for foliar or stem base application. When 2,4,5-T is used for stem base application, diesel fuel oil or kerosene is used as the carrier. Diesel fuel oil and kerosene are effective herbicides for stem base treatment of mesquite, huisache, and other woody plants (Figure 3-11). Individual-plant treatments are usually more effective than broadcast treatments with the same herbicide when plant kill is the evaluation criterion.

Hexazinone effectively controls oaks, elms, hackberry, huisache, mesquite, hercules club pricklyash, junipers, and Chinese tallow trees. As with tebuthiuron, two growing seasons are required to obtain the full effect of hexazinone application. During this period, treated plants may defoliate and refoliate several times. Because a higher concentration of herbicide may be applied to a given area with the briquette formulation than with the pelleted formulation of tebuthiuron, some species (e.g., Chinese tallow tree) that are only suppressed with pelleted formulations are killed with the briquette. Picloram pellets are more commonly used for individual-plant treatment than for broadcast application. They are often used for control of Macartney rose and pricklypear.

Individual-plant treatment is best used for maintenance control of thin stands of brush. Thus, forage release after treatment is usually minimal. Individual-plant treatment may be used to selectively thin a brush stand and to control brush in selected areas while leaving brush in other areas.

Environmental conditions for application of herbicides to individual plants are similar to those for broadcast application. Hexazinone application requires conditions similar to those for application of tebuthiuron. However, best results are obtained with basal treatments of 2,4,5-T in diesel fuel oil or kerosene, diesel fuel oil alone, or kerosene alone when the soil is dry. Care must be taken when applying soil-active herbicides near desirable trees and shrubs. To prevent injury to desirable plants, soil active herbicides should be applied no closer than three times the canopy diameter of the desirable plant.

Prescribed Burning

The primary goal of prescribed burning usually is to suppress brush, since fire usually does not kill many woody species. For a plant to be killed by fire, it must be incapable of resprouting once its aerial portions have been burned. Most Texas brush species, however, resprout from buds located on the stem base and below the soil surface on roots or on rhizomes. Thus, the effect of fire on these plants is similar to that of any method of top removal, such as mowing or shredding (46).

Prescribed burning has advantages not associated with other brush management techniques:

1. Increased palatability, utilization, and availability of forages.
2. Improved distribution of grazing animals.
3. Satisfactory results on soils and terrain where other methods may not succeed.
4. Minimal soil disturbance.
5. Absence of chemicals.
6. Compatibility with wildlife habitat requirements of many game species.
7. Suppressed parasite populations.
8. Lower costs (compared with other methods).

A major constraint to effective prescribed burning is the amount and distribution of fine fuel required to carry the fire, generally from 2,500 to 3,000 pounds per acre of evenly distributed grass, dead leaves, and litter.

Grazing deferment during the growing season before burning usually is required to achieve an adequate fine fuel load. In many situations, the degree of brush infestation limits the area's capability to support a fire. Some brush control treatment before burning may be required to produce adequate amounts and distribution of fine fuel. Therefore, prescribed burning often is used in combination with other brush management practices and as a maintenance measure.

Biological Methods

Although biological brush control is appealing, because natural enemies are used to reduce an undesirable plant species, few successful biological methods have been used in Texas. The most successful has been the use of goats. Because they are browsers, goats can control plants such as oaks, greenbrier, sumacs, hackberries, and several of the South Texas mixed brush species. When browse availability is limited, however, goats will consume significant quantities of forbs and grasses. Thus, careful grazing management is necessary to provide brush control but prevent damage to desired forbs and grasses. Although goats have been used extensively in Texas to control brush, problems with predators have restricted their use in many parts of the state.

4

Selecting IBMS Components

C. J. Scifres and W. T. Hamilton

The IBMS master planning flow chart is an organized set of generalized functions (see Figure 2-1). Each of these functions must be expanded into a series of subroutines for actual application of IBMS principles. This chapter illustrates how those subroutines are developed and brush management technologies are selected. Once the applicable brush management alternatives have been identifed, the remaining planning functions must be completed simultaneously. For example, wildlife habitat and grazing management considered as the brush management alternatives are evaluated in order to develop the system.

Information in Chapter 3 provides a basis for selecting alternative brush management methods based on their mode of action and the expected general outcome. However, since each brush management problem is unique and no two ranch firms operate with identical management goals, a critical step is to develop brush management alternatives (Figure 2-1) to meet the needs of the specific situation. Some of these decisions may require the specialized expertise available from the State Cooperative Extension Service, Soil Conservation Service, private consultants, or other technical sources. However, many of the basic decisions can, and should, be made by ranch personnel who are most familiar with the range resource.

Development of subroutines into simple flow charts stimulates pertinent questions and organizes necessary information into a useful form. Primary elements of such flow charts include nature of the problem, applicable technologies for initial (primary) and follow-up (secondary) treatments, and contingency considerations. Such information is most easily developed when the brush problem is a single species, rather than a mixed-species stand, and when a background of research information and management experience is available. New information and products are constantly being developed, however, and availability of methods may vary among locations and even years. Obviously, planning functions must be updated periodically to accommodate changes and new developments.

The following section deals with Macartney rose as an example of the processes required for developing a working decision-making system, huisache as an example where soils play a major role in method selection, and several other species typical of the south Texas mixed-brush complex. Information presented here should not be considered as all encompassing; instead, it illustrates the necessary planning elements and underlying logic.

Aids for Decision-Making

Obviously, one cannot logically consider brush control methods without first defining the characteristics of the problem. *Definition of the nature of the problem is imperative as the first step in the decision-making process.* The Macartney rose problem, for example, may range from scattered plants or isolated clumps, which can be treated individually, to undisturbed dense stands, which require broadcast treatment (Figure 4-1). There is a set of alternatives, developed by research and producer experience, for treating each of these different kinds of Macartney rose stands. Since the primary methods vary in initial effectiveness and cost, requirements for follow-up treatment, and timing of secondary practices, management should carefully consider the applicability of each alternative technology (see Chapter 3) before selecting treatments.

Alternatives for effectively treating small areas with light-to-moderate cover of Macartney rose regrowth may include prescribed burning or herbicide application; most mechanical methods are not effective except for short-term canopy suppression (44). Prescribed burning, a relatively inexpensive, rapid method of reducing the Macartney rose canopy cover, has gained considerable acceptance by range livestock producers. Therefore, in Figure 4-1, the decision point "Prescribed burning viable option?" immediately follows the characterization of light-to-moderate brush stands. This decision point requires management to consider all aspects of prescribed burning as they may apply to their

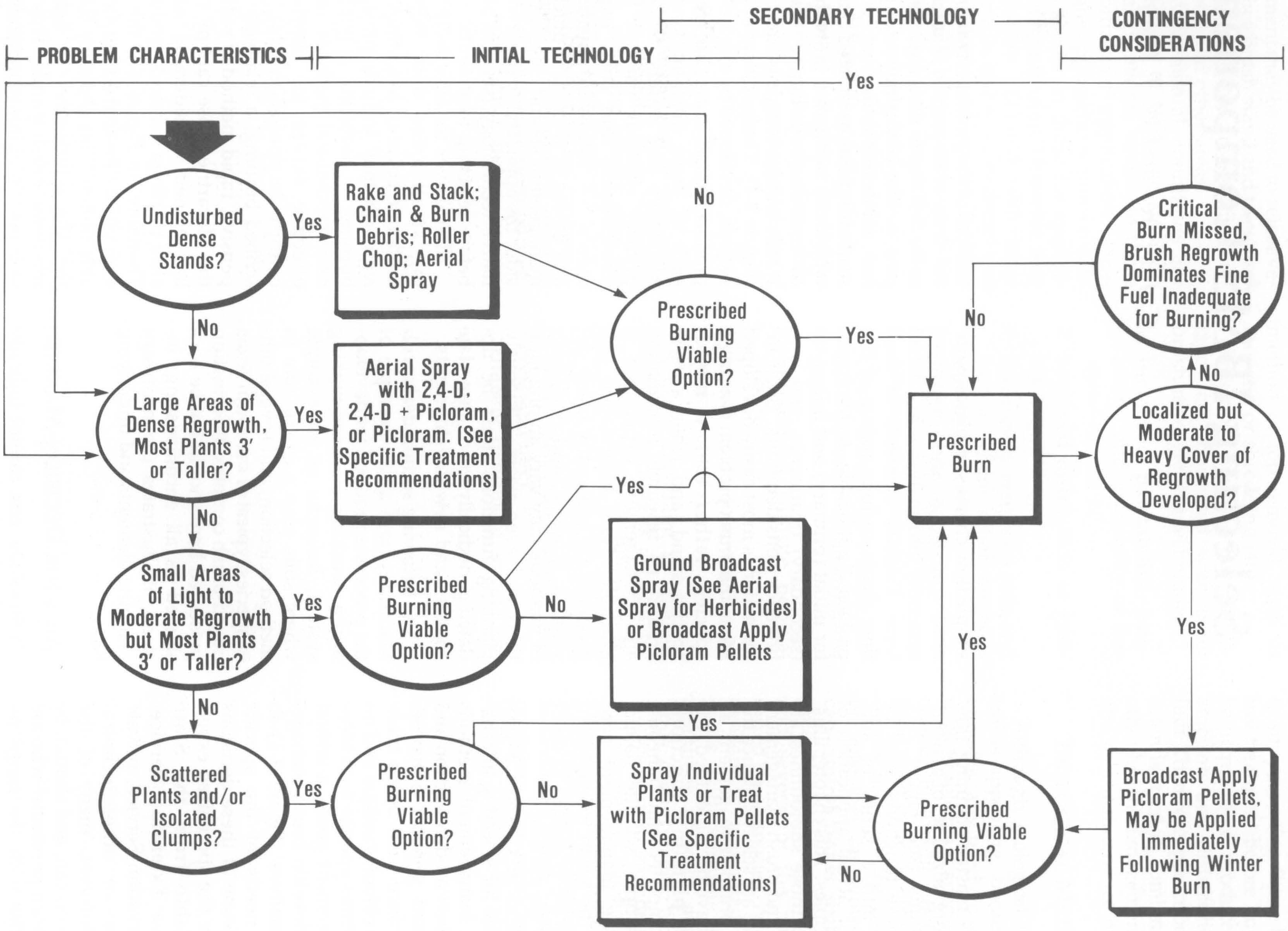


Figure 4-1. Example of a decisionmaking flow chart that might be used in selecting methods for Macartney rose management. Decision criteria are biologically based and may be overridden by personal preference, pr[illegible] economic outcome, or other management considerations.

specific operation and to stated management goals (e.g., expected response of wildlife may be considered a positive attribute). Prescribed burning may not be a viable option for a number of reasons: 1) Management has reservations concerning the practice. 2) Fuel load development (via grazing deferment) will cause undue inefficiencies with other management practices. 3) Topography does not lend the management unit to burning. 4) Ranch personnel are not adequately trained to conduct the burns.

For the sake of brevity, other decision points, unique to each technology, are not included in Figure 4-1. For example, a decision point "Aerial herbicide application viable option?" should precede herbicide application. The answer must consider the potential for spray drift to adjacent areas which might support herbicide-susceptible crops, legal restrictions on times of application of certain herbicides, timing of application relative to susceptibility of the woody species, need for contracting work to custom applicators, and (or) other considerations. Once the basic flow chart is developed, appropriate decision points for each of the alternative technologies become obvious.

The flow chart should include feedback mechanisms that allow planning flexibility through the time frame selected for evaluating the practices (planning horizon). For example, if the original undisturbed stand of Macartney rose has been reduced by mechanical methods and prescribed burning is not a viable option, the flow chart (Figure 4-1) feeds back to the original problem characteristics. If prescribed burning is a viable option, contingency plans should be developed for circumstances such as a missed critical burn or localized areas missed by the burns. These feedback loops provide a working continuum for management planning.

Technologies suggested in Figure 4-1 represent the latest control methods for Macartney rose, but research is constantly exploring new developments and refining established methods. In addition, as previously noted, the availability of specific methods changes from time to time. For example, much of the original research on herbicides for Macartney rose management systems was conducted with the commercial mixture of 2,4,5-T + picloram, but as of the 1984 growing season, that particular herbicide combination was not commercially available. *Therefore, working flow charts must be updated periodically to include the latest available herbicides and other technologies.* Updating the flow chart with new information, including information gained from applying selected technologies during implementation of the system, lends flexibility and refinement to IBMS planning.

Decision-Making For Huisache

The Macartney rose example emphasizes stand characteristics as the first consideration in method selection. The discussion assumes that the stands occurred on homogenous soils, specifically on Blackland (Victoria-Lake Charles clays) range sites.

A similiar scenario may be developed for huisache, another single species problem. The influence of soils is the first consideration in development of huisache management systems (Figure 4-2). For example, rootplowing on the Coastal Prairie leaves clay sites extremely rough and presents management problems for many years following treatment (36). Individual plant grubbing is more efficient on clay loam–loam soils than on clay soils. Moreover, if dense stands are grubbed on clay soils, the land surface may be left rough as after rootplowing (4,53). The decision-making process must consider these treatment aftereffects and should select alternative methods that best suit the particular kind of problem and soils.

Soil characteristics are also extremely important in other decision-making scenarios. For example, efficacy of tebuthiuron decreases as soil clay content increases (14). While the application rate often may be adjusted to overcome the influence of clay, in some cases, soil characteristics may require alternative technologies.

Decision-Making For Mixed Brush Stands

As the number of species in a mixed brush stand increases, the decision-making process becomes more dependant upon matching appropriate technologies with the primary problem species. Two woody species sharing the same range site may vary significantly in their response to any particular control method. For example, broadcast applications of tebuthiuron pellets may effectively control blackbrush acacia, spiny hackberry, and whitebrush but be ineffective against honey mesquite, lime pricklyash, and pricklypear (56). Applications of picloram pellets may control pricklypear, blackbrush acacia, and spiny hackberry, and partially control lime pricklyash and whitebrush, but be ineffective against honey mesquite. Roller chopping may effectively remove the tops of all these species and suppress all species except pricklypear for 2–3 years, but it may also increase the cover of cacti.

Obviously, problem species must be targeted on a priority basis, and this gives special importance to an accurate resource inventory (see Chapter 2). Moreover, since the relative amounts of the species in the stands may vary significantly with range site, the particular pattern developed for wildlife (see Chapter 5) must be considered when selecting brush control methods. This emphasizes the importance of recognizing that no part of the planning process can be conducted independently; rather, all parts must be conducted simultaneously.

For this example, we arbitrarily decided that the species accounting for at least half of the brush composition, based on canopy cover, should be the target species. Of course, other criteria may be used to meet specific land management needs. We then developed

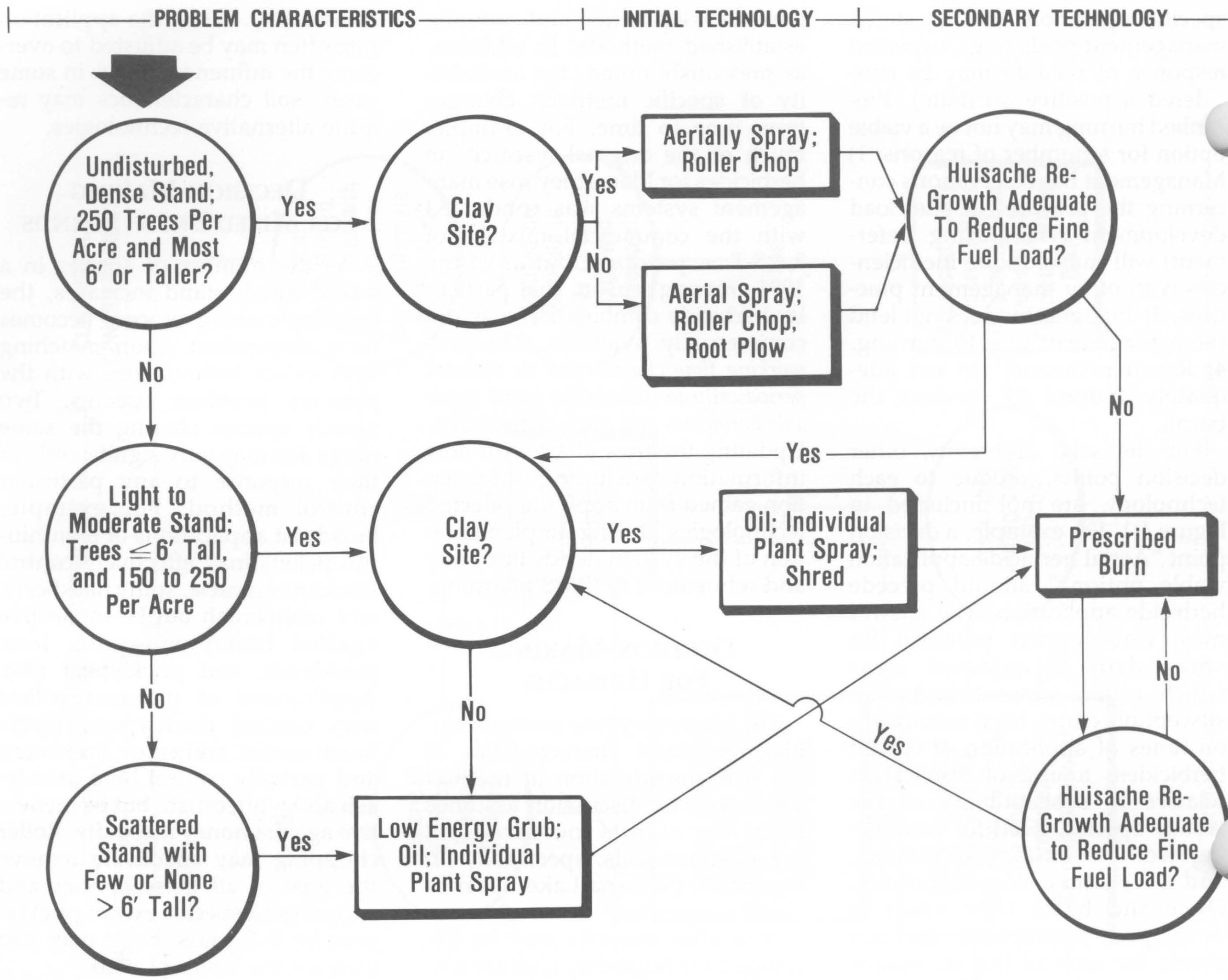


Figure 4-2. Example of a flow chart that might be used in selecting methods for huisache management. Decision criteria are biologically based and may be overridden by personal preference, economics, or other management criteria.

decision-making flow charts wherein honey mesquite and twisted acacia, blackbrush acacia, whitebrush, and pricklypear were targeted (Figures 4-3–4-7). While the response of the targeted species is the first consideration in selecting a primary brush control method, the response of associated woody species must also be considered to avoid selecting a method that effectively suppresses the primary species only to release associated tolerant woody plants to become serious management problems. The projected response(s) of associated woody species thus is a major criterion for selecting secondary practices.

As in the Macartney rose and huisache examples, the decision-making flow chart for honey mesquite or twisted acacia starts by defining the nature of the problem (Figure 4-3). This precise characterization of the density, growth form, size, or distribution of the target species is critical to identifying technically feasible treatment alternatives. The first decision point establishes whether reseeding is necessary. If not, the flow chart proceeds to evaluation of methods which selectively control honey mesquite (throughout the discussion, it will be implicit that the same steps may be used for twisted acacia). The next decision point asks for an evaluation of the pricklypear problem. If pricklypear is an important associated species, certain methods (e.g., chaining, roller chopping, or rootplowing) that may provide acceptable control of mesquite but aggravate the pricklypear problem are eliminated or sequenced after an initial pricklypear control practice. This logic may also be applied in reverse. If the management goal is to reduce the mesquite problem and to increase the availability of pricklypear (for wildlife habitat), then a negative answer at the pricklypear decision point leads to appropriate technologies for consideration. Figure 4-3 is a generalized exampl

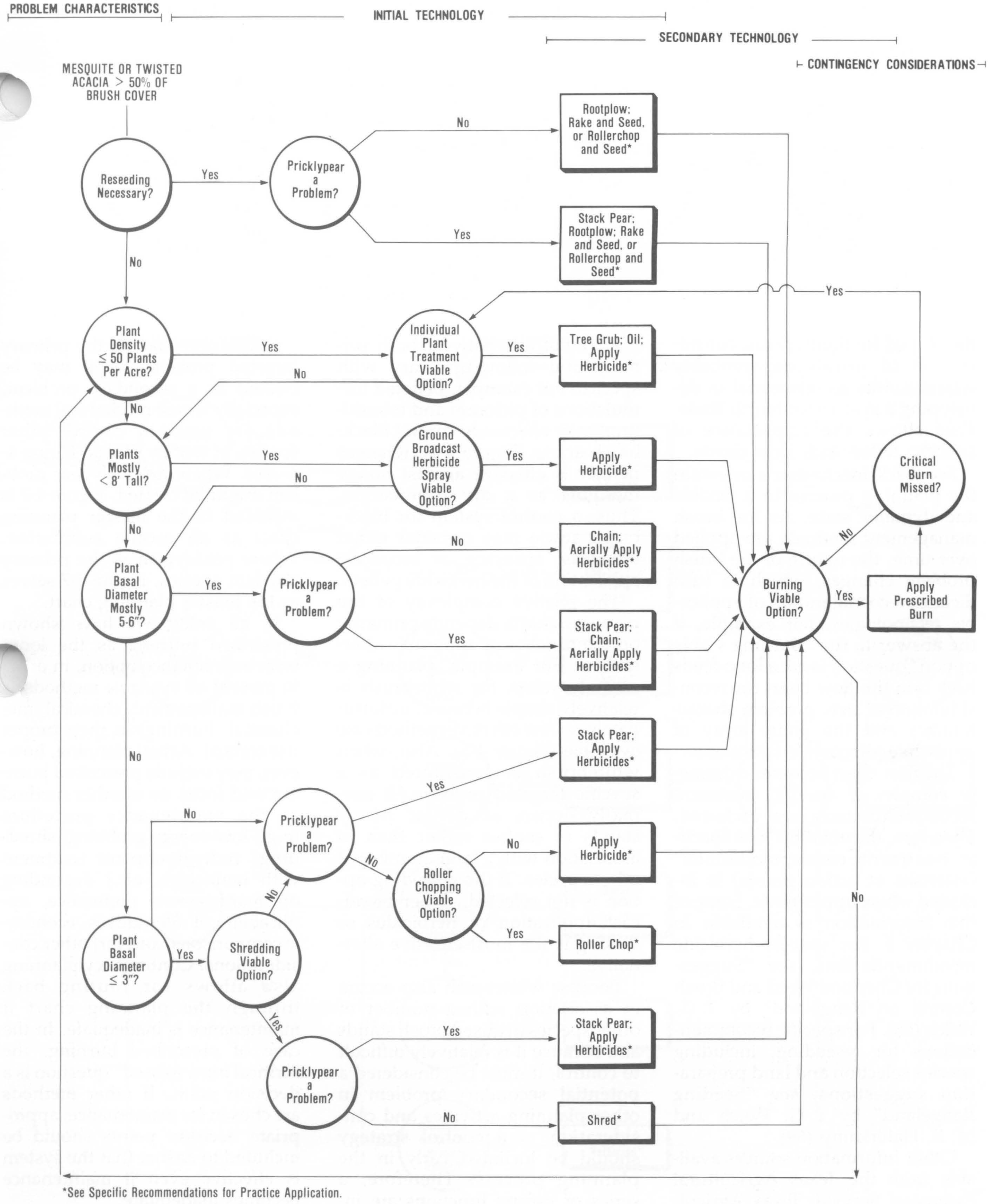


Figure 4-3. Example of a flow chart that might be used in selecting methods for honey mesquite and twisted acacia management in South Texas. Decision criteria are biologically based and may be overridden by personal preference, economics, or other management criteria.

developed for South Texas; consideration of pricklypear probably would not be as influential in developing a system for North Texas. This shows the importance of specific, tailor-made flow charts.

Feedback mechanisms maintain the planning process in a flexible and dynamic state. As the brush management methods are applied over time, the nature of the brush problem changes, which in turn dictates reconsideration of applicable technologies. For example, if the answer to the "Burning viable option" question is *no,* a loop feeds back into the flow chart for reconsideration of new problem characteristics and the entire array of applicable alternative treatments.

The flow chart becomes extremely complex if specific treatment recommendations are included. Therefore, the notation "See specific treatment recommendations" (asterisks at action points) is included where appropriate. Some of this information is available in Chapter 3. For specific herbicide recommendations, see "Suggestions for Chemical Weed and Brush Control on Rangeland" by T. G. Welch (68). For specific recommendations for reseeding, including species selection and land preparation suggestions, see "Seeding Rangeland" by T. G. Welch and M. R. Haferkamp (69).

Other information sources available from the Texas Agricultural Extension Service, Texas Agricultural Experiment Station, Soil Conservation Service, and county Extension agents may prove valuable in making decisions affecting treatment selection and sequencing.

Potential alternatives, both primary and follow-up, vary with species. For example, pelleted formulations of picloram and tebuthiuron may effectively control blackbrush acacia (Figure 4-4), whereas neither is effective against honey mesquite as a dry formulation. Thus, a control system for blackbrush acacia may consider either broadcast spraying or broadcast application of the herbicide pellets.

The relative complexity of the planning charts depends primarily on the number of applicable alternatives. For example, planning a control system for whitebrush is relatively simple because, unfortunately, so few effective methods are available (Figure 4-5). Also, when whitebrush is considered as a specific targeted problem, it normally occurs as dense, heavy stands or mottes rather than in association with a large number of other species. If the reseeding option is not selected, either broadcast application of herbicides or disking is the most effective alternative.

Because whitebrush also occurs in association with a number of other species in mixed brush stands and because it is relatively difficult to control, it must be considered a potential secondary problem in other planning activities and consideration of a control strategy should be included early in the planning process. Therefore, a series of escape functions are included at appropriate points in the planning chart for mixed brush (Figure 4-6) which route the master plan to the subroutine (Figure 4-5) for whitebrush.

Pricklypear may be the primary targeted problem, or it may be created as a secondary problem, especially where mechanical methods are used to control other species of woody plants (Figure 4-3–4-6). Where a pricklypear problem might be created, Figure 4-7 is included in the master planning chart as an escape subroutine. Where pricklypear is the primary problem species, Figure 4-7 serves as the master planning chart.

In all cases, we have shown prescribed burning as the long-term maintenance option, in order to present all available methods of brush management (chemical, mechanical, burning) in their proper use context. Actual planning, however, may exclude prescribed burning and focus on another method as the maintenance procedure (e.g., low-energy grubbing, shredding, individual-plant treatment with herbicides, etc.) depending on management preference, applicability of alternatives, economic comparisons, and (or) other considerations. Contingency planning also allows for routing back through the planning chart if maintenance is inadequate. In the case of prescribed burning, the "critical burn missed" question is a decision point. If other methods are chosen for maintenance, appropriate decision points should be included to ensure that the system is effective even if maintenance becomes inadequate.

The planning process presented here is an example only. The logic exercised can be used to develop custom-designed planning aids to meet specific problems.

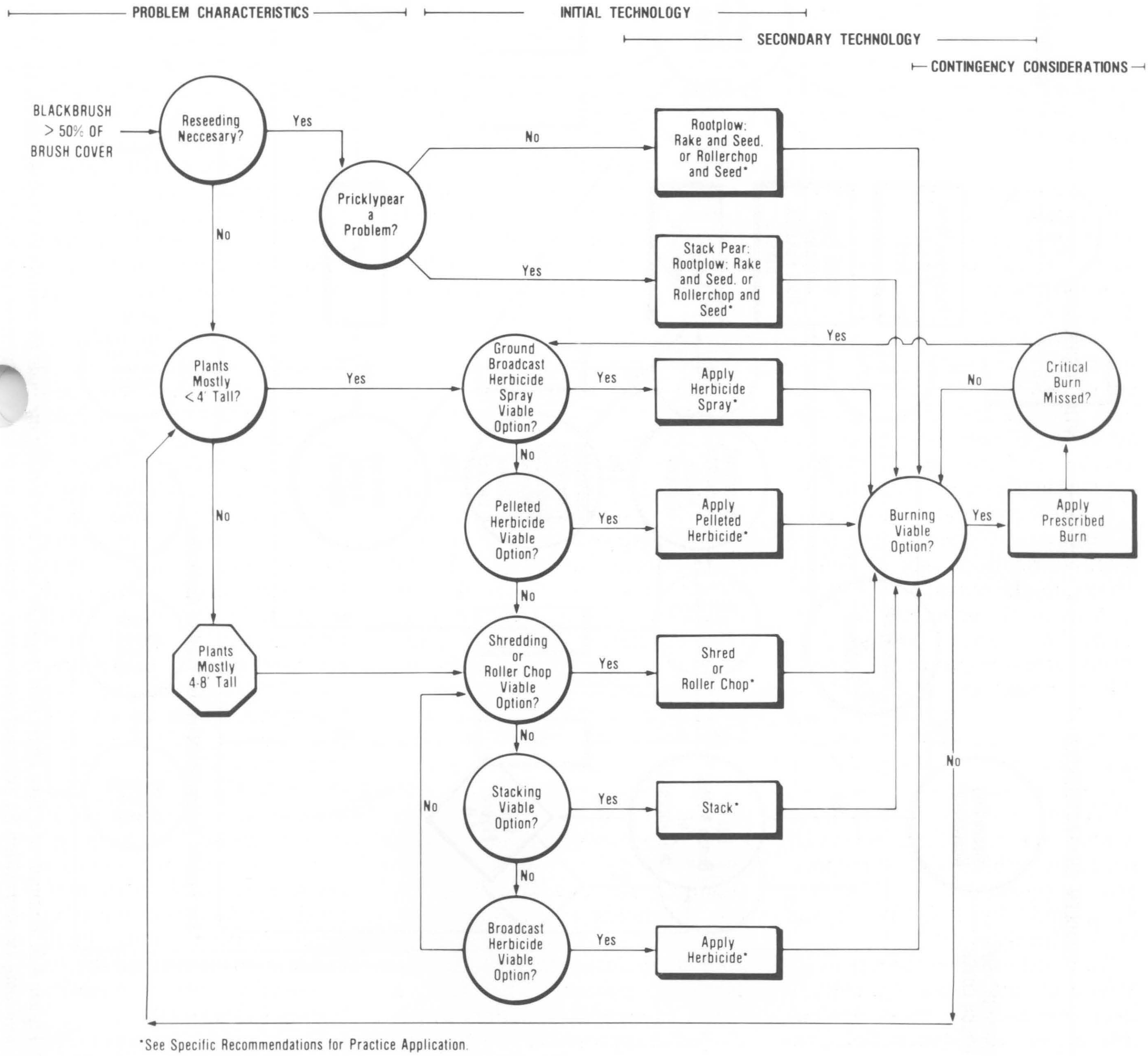
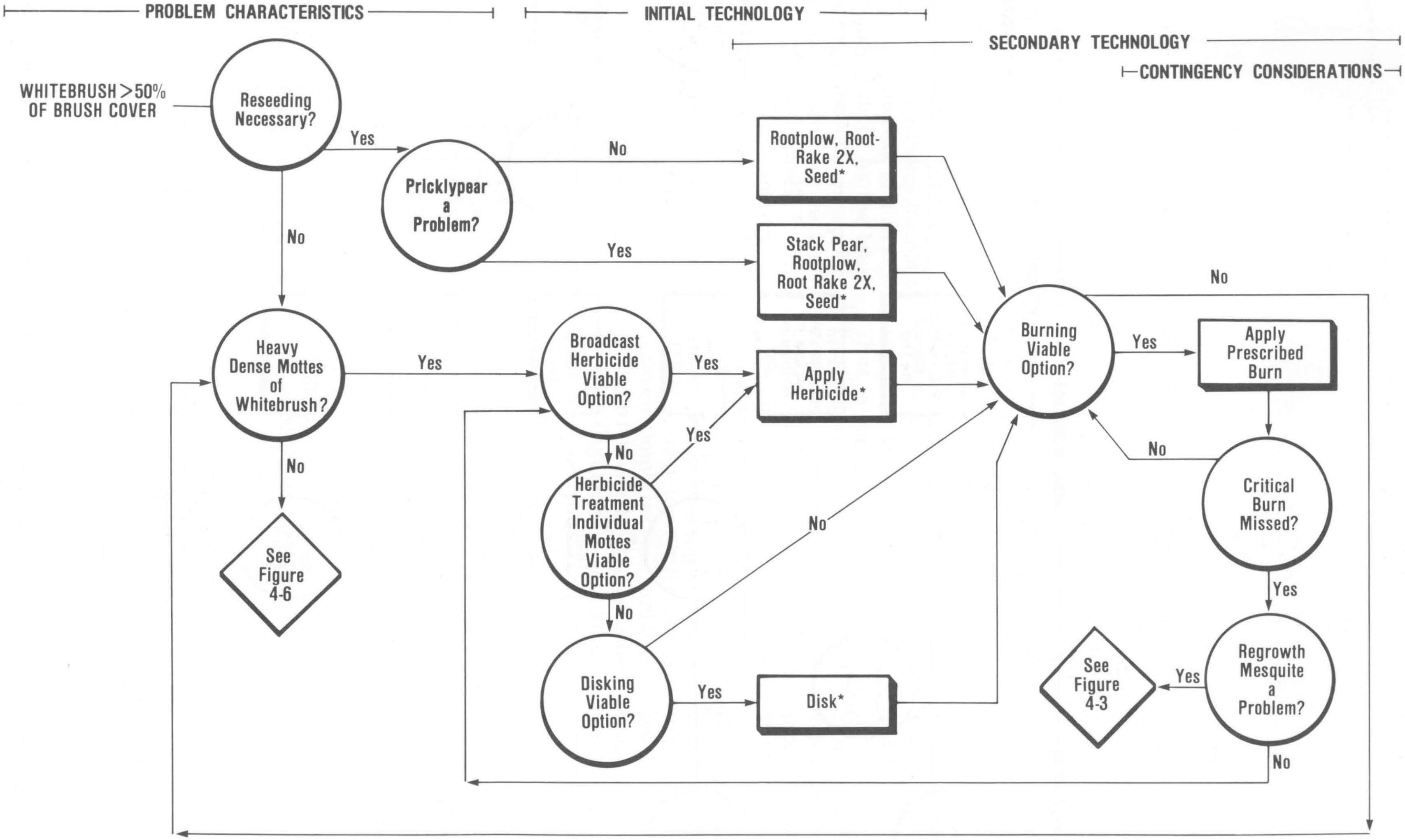


Figure 4-4. Example of a flow chart that might be used in selecting methods for blackbrush acacia management. Decision criteria are biologically based and may be overridden by personal preference, economics, or other management criteria.



*See Specific Recommendations for Practice Application.

Figure 4-5. Example of a flow chart that might be used in selecting methods for whitebrush management. Decision criteria are biologically based and may be overridden by personal preference, economics, or other management criteria.

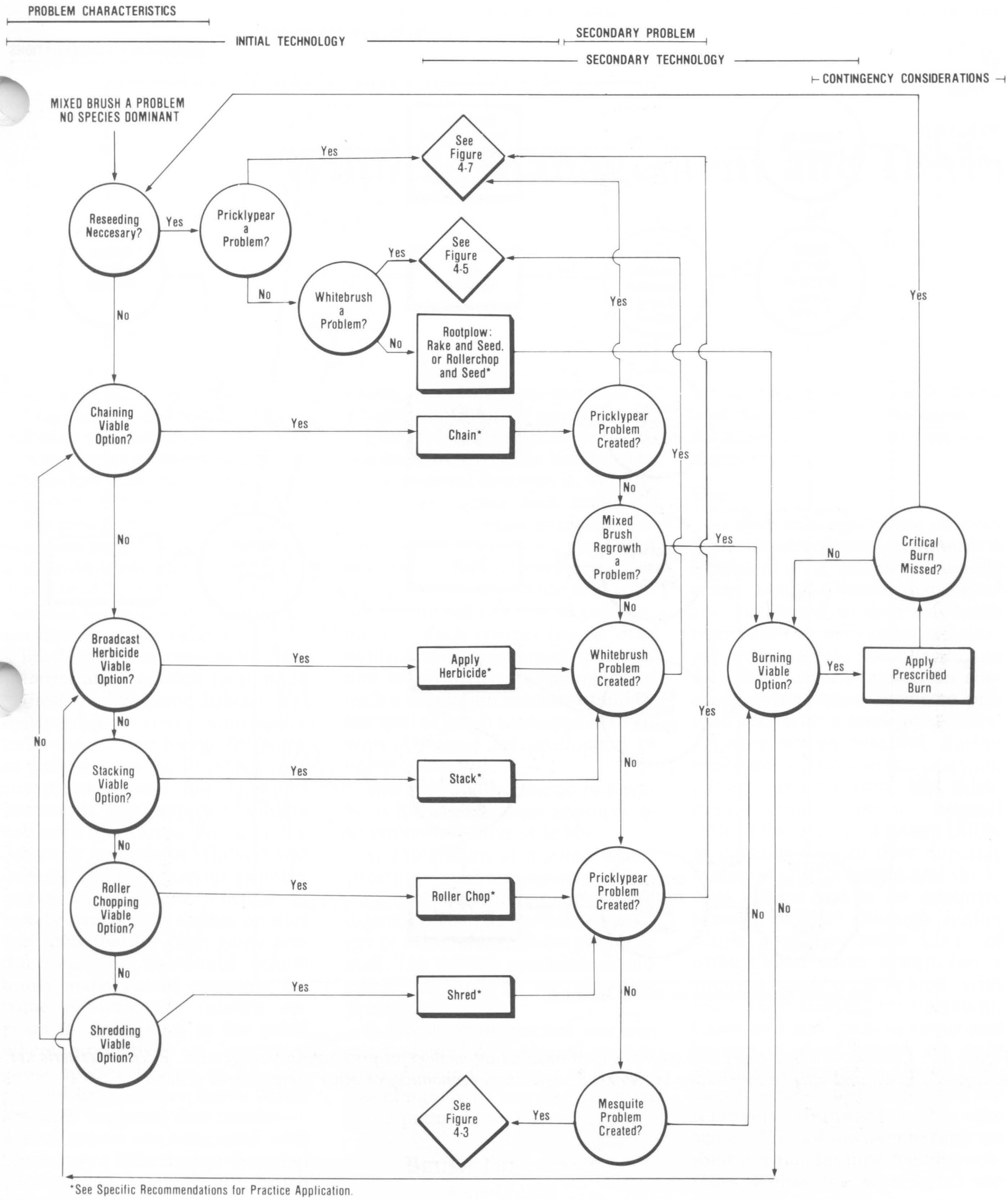


Figure 4-6. Example of a flow chart that might be used in selecting methods for mixed brush management where no particular woody species is a dominant problem. Decision criteria are biologically based and may be overridden by personal preference, economics, or other management criteria.

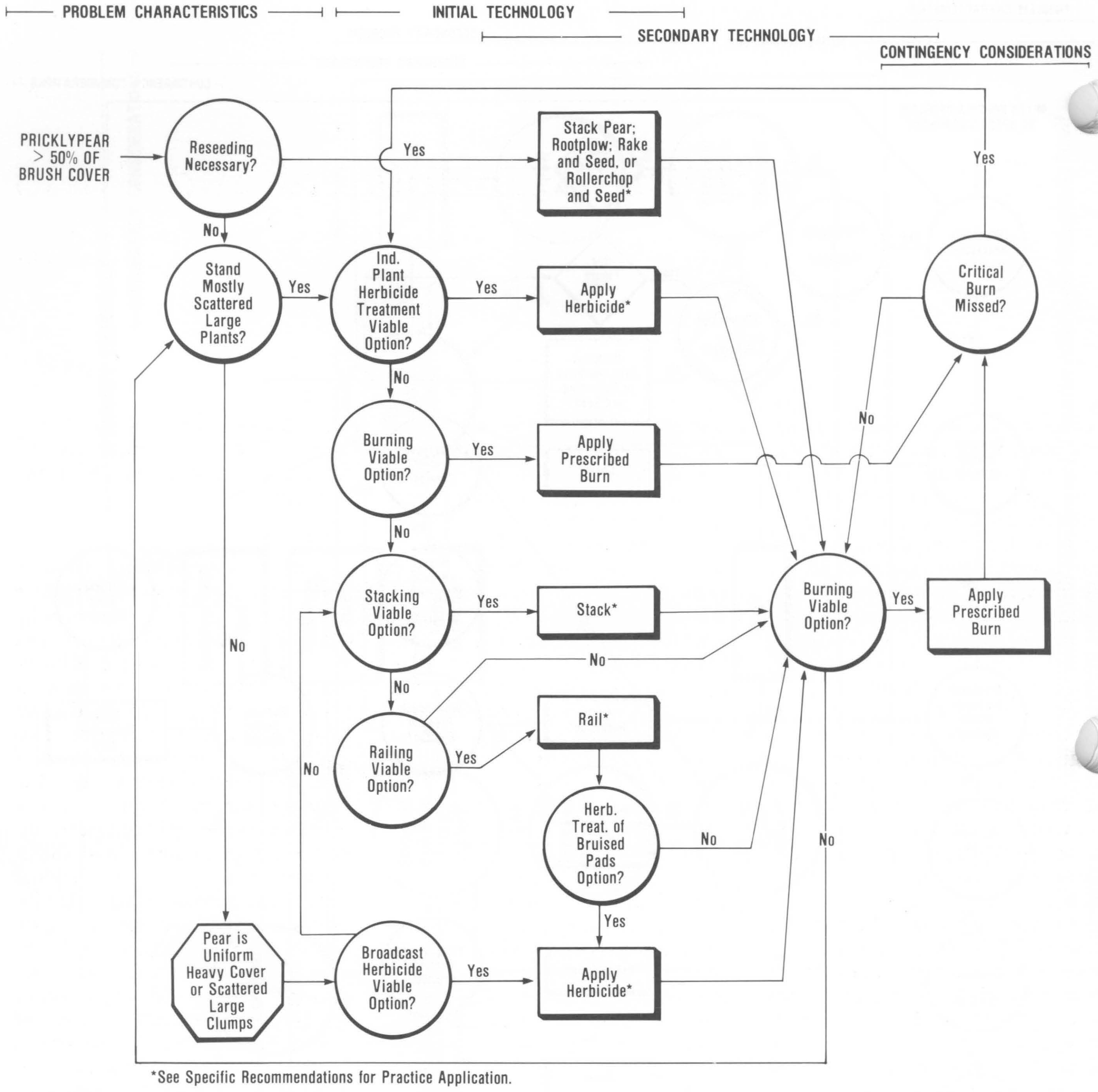


Figure 4-7. Example of a flow chart that might be used in selecting method for pricklypear management. Decision criteria are biologically based and may be overridden by personal preference, economics, or other management criteria.

5

Wildlife Management and IBMS

J. M. Inglis

Under present economic and social conditions, and with sufficient planning and action, income from hunting leases on many South Texas ranches can easily match or exceed that from livestock. If a ranch firm plans to derive income from hunting leases, integrating wildlife concerns into the design of brush management treatments is essential because some treatments can damage game habitat.

Brush stands in many South Texas areas are too thick to provide highest quality game habitat. Excessive brush cover suppresses forbs and browse forage for game as well as grass for livestock consumption. Brush management treatments can improve wildlife habitat in these areas. Based on the economic analysis of Whitson and Scifres (71), brush management becomes increasingly feasible as woody stands grow thicker on sites with potential for high game production. The threshold where brush management practices become economically feasible appears to correspond to the point where productivity of important game species begins to be suppressed by excessive brush cover. Research suggests that maximum deer numbers are associated with brush only a little thicker than that which could barely justify brush control treatments from an economic basis (23). Maximum quail numbers are associated with even less brush. Among manageable game species on many South Texas ranches, only javelina strongly favor extensive thick stands of brush, especially those stands with a high proportion of pricklypear.

Even though brush removal often improves wildlife habitat, too much removal destroys it. Wildlife managers retain and maintain brush on key areas because each game species requires a pattern of woody vegetation to act as a cover screen, to provide shade and shelter, and in some cases to produce browse. Each species has its own demand for interspersed openings and brush areas. Maintenance of such a vegetation mosaic should be the goal of brush management systems designed for production of game animals.

Two rules with general implications for wildlife seem appropriate to implementation of IBMS:

1. Integration of a game enterprise into brush management planning probably will require wildlife expertise, such as a wildlife manager or a consultant on the planning staff. The wildlife specialist should participate fully in the planning process.
2. Brush management on any ranch should be designed so that the ranch, independent of its surroundings, will support its own game populations (8).

Brush Treatment and Game

This section describes brush management practices that favor whitetailed deer, quail, and javelina. Similar guidelines could be written for other game species, but these three account for most wildlife management in South Texas, and they serve as good examples for relating brush and wildlife management.

Deer

A deer manager's first concern in the design of brush treatments is retention of a mosaic of woody cover screen—brush distributed and structured so deer can break visual contact with perceived danger within a few seconds (Figure 5-1). Being inside or near an adequate cover screen seems to provide deer with a sense of security.

Cover screen retained during treatment will vary in composition, pattern, growth form, and thickness depending on the original state of the untreated brush. Utility as cover screen for deer depends mainly on brush height and thickness. Three feet is an adequate average height, although higher brush possesses other kinds of utility. Ideal cover screen has a thinned quality compared with most brush targeted for treatment. Grass and forb ground cover and browse at deer height are only moderately suppressed by an ideal stand, so food supplies for deer are relatively abundant within the screen. This allows deer to carry on their normal daytime feeding activities within the security of the screen.

Optimum brush thickness allows deer to disappear within the screen at a range of approximately 50–75 yards. Utility of cover is less when the cover screen is thicker or thinner. Since brush being treated

Figure 5-1. Woody cover screens allow deer to break visual contact with any perceived danger.

is usually thicker than an optimum cover screen, the utility of untreated brush retained after treatment is often less than ideal.

A plan for cleared and uncleared ground favorable to deer should allow at least one-third of the area to have a cover screen. The mosaic should be designed so that no point is farther than 200 yards from a screen. Square clearings up to one-half mile (880 yards) on a side will often be used in their totality by deer, but local deer densities will be somewhat reduced. A clearing exceeding one mile (1,760 yards) on a side will receive little use near its center, and local deer populations will be much depressed around such a large clearing. The same area of ground cleared in strips or smaller patches could promote maximum deer densities.

Deer respond in different ways to different methods of brush treatment. Mechanical treatments tend to remove brush entirely from treated ground and result, at least temporarily, in total absence of cover screen. Because of soil disturbances, some kinds of mechanical treatment promote high production of forb food supplies. Brush regrowth on mechanically treated ground has low stature, which may increase browse production and availability (6,40). Chemical treatments can be more extensive than mechanical treatments without as much immediate effect. Herbicides temporarily suppress food supplies, but this effect is often followed by a flush of low browse and forbs. The main advantage of chemical treatments is that they do not remove the cover screen in the short term (63). The screening effect of brush before defoliation is provided to a significant degree by stems. Since stems remain standing after chemical application, the immediate effect of herbicide treatment on cover is not great. Eventually, these stems will collapse, and if regrowth does not replace the cover, results will approximate mechanical treatments. This is a significant consideration, inasmuch as one goal of IBMS is to extend the effect of brush treatment by secondary treatments, such as prescribed burning.

Many ranches have special or unique brush features which, if treated appropriately, will contribute additional quality to a designed brush mosaic. Major drainage lines and their main branches should be dealt with carefully (12,34). Because of favorable moisture conditions and soil fertility, tall brush and trees in drainages develop structural features preferred by deer for midday loafing and bedding. Much-used loafing and bedding sites should be protected from brush removal. At the same time these comparatively fertile bottomland sites have great potential for producing nutritious deer (and livestock) forage, so brush treatment in the form of thinning or segmented clearings along the length of the drain is sometimes appropriate. Local deer densities in the vicinity of these drainages, given an appropriate interspersion of cover and openings, will often be at least twice the densities in nearby areas that lack drainage lines (12).

While extremely dense thickets are generally a negative habitat feature, some scientific data support hunter lore that mature bucks, which are particularly intolerant of disturbance, have a demand for thickets as escape cover (65). Thus, including a few dense thickets in a brush mosaic seems appropriate. These need not be abundant or extensive; one or two thickets on each square mile should be favorable to herd quality. Brush should be retained in the vicinity of watering sites.

Carefully designed livestock grazing systems coordinated with brush management are favorable to deer when they contribute to range improvement, reduced competition with livestock, and increased habitat stability. Given an adequate cover pattern, good range condition favors deer because it promotes diversity and abundance of high quality perennial forages. Diversity reduces competition between deer and livestock, as each animal selects its favored forages. When high quality perennial forbs and browse are depleted on ranges in poor condition, deer forages "boom" and "bust" as annual forb and grass populations respond to variations in rainfall. Conversely, improved range condition favors stability of deer forage. Since browse is fallback forage for both deer and livestock during drought periods, deer–livestock competition is intensified when range condition is poor. Deferrals of livestock grazing as part of grazing management also reduce this competition.

Quail

There are two species of quail in South Texas—bobwhite and scaled (or blue) quail. Their habitat requirements are not exactly the same; scaled quail prefer sites with less, or more dispersed, brush. Even so, management doctrine for the two is similar enough that a single description of habitat requirements will apply to both.

Quail in South Texas are likely to be most abundant on rangelands in "low good" range condition. They depend on abundant forbs and perennial herbaceous ground cover in association with an appropriate mosaic of woody escape coverts. This means that land treated for brush management is generally favorable to quail once a perennial ground layer is well established. Quail are much less successful where ground cover is suppressed either by extensive areas of brush overstory or by overgrazing.

Cover requirements of quail are satisfied by several types of vegetation. The most fundamental of these is woody cover used to escape danger and to serve as loafing sites. Ideal escape coverts consist of woody plants with low crowns of intermeshed branches (60). They should hug the ground but be open underneath to quail height, to allow birds freedom of movement, and be 10 or more yards in diameter. Quail fly to refuge, so ideal spacing provides that all points in the habitat be within flight distance (roughly 100 yards) of an escape covert. Coverts must be associated with adequate herbaceous ground cover.

On areas where brush treatments have been applied, such coverts consist of brush regrowth. Because of the typical growth form of mature brush in much of the region, maintenance brush treatment is often required to keep stature low. Brush taller than waist high contributes little to quail habitat. Small mottes of taller brush plants with a compact cluster of protected understory woody plants, grasses, and coarse forbs are commonly used as escape cover in South Texas, but utility is less than ideal.

High quality herbaceous ground cover consists of perennial bunch grasses with associated forbs spaced so the birds can feel secure but still have freedom of movement on the ground surface. This provides a cover screen making the ground between escape coverts accessible to feeding quail. Protected sites with well-developed stands of this type of cover are typically used for nesting. Creeping low brush and pricklypear stands often play the role of mixed escape and ground cover. Coarse forbs and annual grasses may also play this role temporarily, but they tend to collapse in the winter forcing the birds to move away.

Large areas dominated by close-set stands of one grass species, such as buffelgrass, coastal bermuda, or bluestems, do not satisfy the ground cover requirement (27). Dense stands of grass impede the activities of quail. Furthermore, they competitively exclude forbs and other grasses that produce quail food. Grazing has a positive influence in opening up stands of bunch grasses, but grazed bermudagrass creates a turf that quail cannot use.

Quail eat seeds, insects, young green growth, and some fruits and mast. Since most of these items are present in unlimited quantities during the growing season, quail management focuses on assuring winter feed availability. This is less a problem in South Texas than elsewhere because green sprouts persist through the winter. Even so, management should promote native forbs with hard overwintering seeds of the appropriate size, such as crotons, ragweeds, dayflowers, sunflowers, etc. Moderate grazing will open up the grass stand and allow the establishment of these forbs.

A quail manager's fundamental brush control concern involves interspersed openings in the brush with scattered patches of brush regrowth to act as escape coverts. Establishment of these smaller scale habitat features raises the treated area's quail carrying capacity and tends to stabilize populations. When treated areas lack low woody coverts, carrying capacity will not be as much improved, although any treatment mosaic will constitute a habitat improvement over an extensive dense stand of mature brush.

For several years after brush treatment, brush regrowth will naturally fulfill quail needs for woody escape cover, and if grazing is correctly managed, ground cover also will be improved. However, continued regrowth will result in excessive height of the woody cover, a thinned ground layer, and reduced habitat quality. Maintenance treatments to favor quail should be aimed at holding the brush in the preferred stage.

Patterns of brush treatment should be favorable for quail hunting. Extensive stands of tall brush may hold a few quail, but they have little utility for quail hunters. Small-scale habitat features associated with residual brush in clearings will tend to hold flushed birds in the openings. Given an adequate mosaic of escape coverts and grassy ground cover, openings can be larger than is appropriate for deer. Without adequate low cover, quail will associate mainly with the edges of untreated brush.

Quail populations in South Texas vary greatly in response to variations in range carrying capacity associated with extremes in annual rainfall (27). Classically, quail "bust" during major droughts and "boom" as a lagging function of renewed rainfall. Good grazing management is important to quail management because it reduces the magnitude of these variations.

Javelina

The requirements of these animals in South Texas are so poorly known that there is no well-developed management doctrine. Many South Texas ranchers consider them vermin rather than a potential source of income. Even so, javelina attract some hunters, and they have been successfully developed as a source of income by a few ranchers. A potential seems to exist for further development, which will in turn require habitat management.

The basic concern of javelina management must be the retention of fairly extensive thickets in the brush mosaic. Major drainages, brush around ranch ponds and tanks, and areas surrounding major pricklypear stands appear to be favored javelina sites. Thickets of 10–20 acres within these areas seem appropriate. Javelina social groups of 10–40 animals range over roughly 400 acres, so the brush retained should be an interconnected mosaic over units of this size. Continuity of retained thickets is probably more important than large size. Pricklypear should be protected when it is significant in the plant composition.

Setting Objectives

The desire to make range improvements is often associated with a transition from an extensive to more intensive ranch management philosophy. Associated with this may be a sharpened awareness of the income potential of a hunting lease enterprise and a feeling that such an enterprise should be initiated or upgraded. Since retention of brush to favor wildlife on rangeland often means sacrificing potential livestock forage production, increased potential for brush reinfestation, and compromise in grazing practice, there is a need for economic balance in the decision-making process.

Decisions must be made to determine 1) whether the local wildlife resource has the potential for supporting a hunting lease enterprise, 2) the probable relationship of brush management alternatives to retention of huntable game populations, 3) wildlife management objectives that will have to be fulfilled, 4) wildlife harvest systems, 5) game species to be given priority when developing brush management alternatives, and 6) the form of hunting lease system that might be employed. These decisions then form the basis for setting game management objectives that interact with other IBMS objectives.

The high cost of brush treatments creates a situation where ranchers must often make range improvements on one part of a ranch at a time. This extends the time over which management initiatives must be sustained to obtain overall improvement. Deer management is almost always ranchwide, so brush management on part of the ranch will result in habitat modifications that will affect the deer management system segmentally. Conversely, quail can often be managed on relatively small land units. Long-term game management objectives should, therefore, be well defined at the outset and subjected to periodic review (typical IBMS feedback, Chapter 8) so they can play a coherent role in the ongoing design of range improvements.

Deciding whether the local wildlife resource has the potential for supporting a hunting lease enterprise depends basically on ranch size and density of game. These determine the number of units available to be harvested from which the maximum number of marketable hunter days can be estimated. Beyond this, the economics used to determine operational feasibility are similar to those used in the analysis of any other commodity. For example, a 2,500-acre ranch with one adult deer per 20 acres will carry 125 deer. Assuming both sexes are hunted, a 20 percent harvest quota would imply 25 units to be harvested. These could be marketed on the basis of day-hunts, a season lease for a club of 10–12 hunters, or some other formula depending on ranch goals, objectives, preferences, and priorities. The number of harvestable units and the marketing method should allow projection of potential income for use in economic analyses.

The fundamental objective for making compromises in brush treatments to favor game is retention of game populations. Brush management in well-designed patterns will often result in improved game habitat but not necessarily in significant increases in animal numbers. The population response may be great or small as a function of whether the beginning point for brush management is a heavy infestation of brush or a stand of brush so thin that it is marginal for treatment.

Increases in deer numbers resulting from treatment of heavily infested ranges should be moderate. Response of deer numbers to treatments of lesser infestations may be small or even negative. If low brush and herbaceous cover is retained in clearings, quail almost inevitably show great positive response to opening up of dense infestations and less, but significant, response to economically marginal treatments. Javelina would probably respond negatively in either case. In all cases, visibility and accessibility of game should improve, so that hunters will perceive an improvement even when populations decrease somewhat.

The wildlife management goal of producing healthy and productive game populations may be complicated by the need for a carefully designed harvest system. In the case of quail, a healthy and productive population should be a straightforward product of range improvement practices designed for quail. In the case of deer, however, range improvement may result in increased deer numbers but not in improved animal condition unless an organized harvest system is operating to prevent overpopulation (i.e., high densities of animals in poor physiological condition). Food shortages regulate deer numbers of many underhunted deer populations. Population density naturally increases to a point where deer food supplies are suppressed, animal condition declines, mortality increases, conception and fawn survival decline, and finally, a stable "overpopulated" state is reached. Conversely, controlling deer numbers with a well-designed harvest system reduces pressure on deer forage and results in better animal condition.

This interaction between numbers and condition of deer is a function of the design of hunting systems. Some ranch firms utilize overpopulation as the basis for a hunting system. Hunters will pay a price for having a high likelihood of killing their limit of deer, and some will accept low animal quality to gain this end. However, the abundance and size of trophy animals may affect pricing significantly. New deer harvest systems aimed at increasing the relative abundance of trophy class animals generally focus on overcoming problems associated with overpopulation. Methods include harvesting females to reduce reproductive potential of the herd and selectively harvesting bucks to favor production of animals with large antlers. High-priced specialty hunts are designed to harvest the trophies.

The different game habitat requirements strongly interact with the design and intensity of brush managment systems. This interaction may determine which game species is given priority in developing a ranch firm's hunting enterprise. Less constraint is imposed on brush management practices by quail than by deer enterprises. There is less necessity for biologically monitoring the population and using technical harvest systems than with deer. Furthermore, quail hunting may be less intrusive than deer hunting on ranch operations. Although income from small quail hunting leases rival those from deer, the market is less well developed. Furthermore, quail populations "boom" and "bust" in response to variable weather, giving less resource stability. South Texas has a long-established tradition of deer leases, and even though more compromise of brush management is required and deer management is more technical, there is more resource stability. A combined enterprise could provide flexibility by allowing more diverse brush management practices.

Leasing Systems

If brush management is designed appropriately, it should be possible to maintain an adequate population of game to support a hunting system. However, hunting recreation is the product that produces an economic return. The economic relationship between game populations available for harvest and income actually derived is very elastic. There is a poorly defined threshold of game abundance that satisfies hunter perception of adequate quality in a lease. Above that threshold, income seems to be more a function of aggressive merchandising than game populations per se.

Another important objective in the design of many leasing systems is to accommodate non-wildlife objectives of the ranch firm. A significant number of ranches have no hunting lease program at all; either the ranch is not hunted, or hunting rights are reserved for family and friends. Public relations and payment in kind are often the basis for providing hunting access to business associates of a ranch firm. Even when an organized hunting lease system is in place, it may be operated on a more or less casual basis tangential to the more organized livestock enterprise. Often the result is that management largely ignores this appreciable source of income. In the unimproved situation, this is not too serious. However, when planned range improvement may make major modifications in game habitat over extensive areas, the hunting lease system should play a role in shaping economic policy. Otherwise, the game resource may lose its potential for supporting a hunting lease enterprise.

Cultural and social factors often partially (sometimes wholly) supersede economics as the basis for developing or upgrading a hunting lease system. However, when economics play a significant role, return can be great under several different kinds of lease systems. Nevertheless, no matter what the system, there are operating costs associated with a hunting enterprise—the most notable being merchandising, facilities and services offered, effort expended in biological monitoring and wildlife management, opportunity costs associated with compromises of brush and grazing management, insurance, and legal matters. Furthermore, a leasing enterprise intrudes on ranch operations to some degree. Even so, it has great potential for contributing significantly to net profit.

Implementing Objectives

The basic concern of the wildlife manager in implementing IBMS is design and retention of a brush mosaic. Patterning of brush treatments depends on wildife considerations more than any other management objectives. The design of a favorable habitat mosaic is strongly influenced by range site, kinds and existing pattern of untreated brush, efficacy of different brush management techniques, the ability to establish desired patterns with effective treatments, economic response projected for different brush management systems, and preferences of the ranch's management among economically feasible designs.

When a certain portion of a ranch is scheduled for range improvement, the first step involving wildlife management should be to determine the importance of that segment to the wildlife habitat on the ranch as a whole. Size of area, proportion of the total ranch area, and the importance of this area's contribution to ranch game habitat before treatment all affect wildlife management strategy. A cover mosaic should create patterns that allow the treated segment to carry its own populations of game, to contribute to diversity and interspersion of the habitat in the surroundings, and to favor hunting.

Treatment should be conservative, relative to proportion of total area cleared, when managing deer in a region where adjacent land already lacks adequate cover or where the brush being treated acts as a shelter in a more open regional habitat. Conversely, if the treated area is part of a large region of mature brush thickets on the managing ownership, treatment can be more aggressive.

Laying out a proposed habitat mosaic begins with identification by the wildlife specialist of pretreatment features that have special utility—prime loafing–bedding grounds for deer, for example. These should act as focal points in the pattern of brush retained. Landscape characteristics (terrain, pattern of range sites, brush types, shape of treated pasture, treatment history, etc.) affect the pattern of the residual brush mosaic, so each design effort will be unique. Several possible treatment patterns should emerge from this analysis.

A series of feasible alternative techniques for treating the brush should emerge simultaneously as a result of analysis by brush and range managers. These two aspects of planning are combined to produce a set of feasible pattern–treatment combinations for consideration—i.e., alternative treatments in the IBMS protocol.

Feasibility is finally a function of compatibility of pattern and method of treatment. For example, a pattern of strips cleared on the contour or in a zigzag pattern could be installed by some mechanical methods but probably not sprayed from fixed-wing aircraft. Rectilinear strips could be done either way. A variable-rate pattern, which involves making half-intensity treatments in strips perpendicular to each other, could only be applied from an aircraft (52). Incorporation of prescribed burning in a system will demand deferrals which may not be feasible in the time allotted.

It is likely that only a few candidate pattern–treatment combinations will emerge for which equipment is locally available and which suit the preferences of ranch management. These should be ranked by wildlife specialists in terms of their utility for satisfying game management objectives.

Simultaneously, range specialists in cooperation with economists will be ranking these same candidate combinations in terms of projected forage production and livestock response as reflected by economic response curves (see Chapter 7). Interaction and compromise among management objectives should result in further limitations of alternatives and, finally, in identification of the system that shows the most promise for optimizing income from combined game and livestock commodities.

6

Integrating Grazing Management and Brush Management Strategies

J. W. Stuth and C. J. Scifres

There is no single best approach to melding brush management and grazing management into an overall ranch management strategy. The outcome of each brush management–grazing management combination depends on the variation associated with each of the individual technologies and the degree to which they interact. For instance, optimum response from many brush management procedures requires closely timed deferments from grazing which may be achieved through planned grazing systems, restructuring of livestock herds, and (or) use of land outside the system. Conversely, there are situations where optimum grazing management response cannot be achieved without brush management. A planned grazing system on dense woodlands or shrublands may not improve the range condition unless the brush canopy cover is reduced. Rangeland in South Texas exhibits a strong tendency to revert to a shrub complex after brush management treatment, regardless of treatment or grazing method used (52). Good grazing management, however, may retard shrub reinvasion by increasing desirable grass species, thus reducing niches available for shrub seedling establishment.

Selectivity

Understanding the relative palatability of the various woody plants and the availability of edible parts to the animal is necessary to develop grazing systems which directly impact the brush. Given a choice, grazing animals can extract diets of higher than average nutritional value by selecting higher quality plants and plant parts. Depending on the species of animals, plants can be classed into five major selectivity categories (Table 6-1) (61).

1. *Preferred.* These plants are sought out by the grazing animal; they generally constitute a greater than expected percentage of the animal's diet, considering relative availability in the forage stand. Such preferred plants generally enhance the nutritional status of the animal and are largely responsible for improved weight gain and conception, compared with animals on similar areas lacking the preferred species. Grazing pressure [2] placed on individual plants of this category increases as abundance of these species decreases.

2. *Proportional.* These plants are selected in proportion to their availability in the forage stand. Forage species in this category provide the bulk of the diet and maintain the animal's nutritional state such that it can take advantage (gain weight, conceive, etc.) of more amenable forage conditions as they develop (11). Generally, plants in this category determine the average carrying capacity of a given range.

3. *Force selected.* Plants which animals must be forced to eat, because of severely reduced availability of preferred and proportionally selected species, serve as reserve forage. They play a significant role in allowing the animal to survive adverse conditions, particularly when preferred forages are low in nutritive value or when primary foods have been depleted during dry periods (11).

TABLE 6-1. Selectivity categories of plants in relation to the nutritional and functional roles for livestock on rangeland

Selectivity category	Nutritional role	Functional role
Preferred	Performance	Diet enhancer
Proportional	Maintenance	Bulk
Force selected	Subsistence/supplementation	Survival
Detrimental	Toxic	Death
Avoided	None	Reduced carrying capacity

Adapted from Crawley (11) and Stuth (61).

[2] Used in this context, grazing pressure is the ratio of grazing animals per unit of time to amount of available forage.

4. *Detrimental.* Should grazing animals rely on significant quantities of force selected plants, they may begin to consume detrimental or toxic plants. Many poisonous plant problems can be directly linked to the loss of preferred and proportionally selected plant species.

5. *Avoided.* The remaining class of plants, those which are not selected, include many of the weeds, trees, and shrubs on rangeland. These plants generally do not contribute directly to the nutritional status of the animal.[3] Instead, they generally reduce range carrying capacity by displacing preferred and proportionally selected plants. However, plants in this category can have an indirect but positive influence on the overall nutritional quality of the range. For example, if canopy cover does not exceed 20 percent (53,58), the presence of huisache promotes Texas wintergrass, a cool-season bunchgrass, thus improving forage quality of the overall stand when most warm-season forages are low in quality or not available.

Planning the System

Generally, one of three planning situations emerges during the process of integrating brush management and grazing management into an overall plan:

1. A major investment and management commitment has been made in a grazing system, or systems. In this situation, brush management strategies must be incorporated into the existing grazing system. Usually, only minor adjustment in rotation or short-time rest can be incorporated into the system to accommodate the brush management plan.

2. Another planning situation involves extensive brush management where range development has been minimal. Grazing is generally unstructured, and graze–rest decisions are made on a relatively short-term basis. In such cases, brush management strategies may be based on efficacy, influence on wildlife habitats, and economics. Grazing strategies are then loosely planned around pretreatment or posttreatment requirements for deferment to enhance brush management effectiveness.

3. In other cases, brush management and grazing management are planned simultaneously. This may be the optimum approach for developing the most effective integrated range resource management plan, since a greater array of management combinations are possible. An example of this integrated process appears on page 45. Alternative combinations of brush management treatment sequences and planned grazing systems can be evaluated as to production response and economic feasibility. This planning situation would most likely occur in ranch firms where there is a desire to intensify management planning and production.

Effectiveness of many brush management practices depends on key deferment periods needed before treatment installation to allow desirable species to improve their vigor. For example, pretreatment grazing deferment to allow fine fuel development is essential for effective prescribed burning. The ease of integrating brush management strategies with planned grazing systems over a given time frame depends not only on deferment requirements but also on physical and logistical characteristics of the grazing system. Arrangement of watering locations, pasture shape, fencing arrangement, corral location, road systems, utility right-of-ways within the grazing system, and adjacent land-use practices may limit realistic treatment alternatives. Number of pastures, graze–rest sequences, flexibility in movement of livestock, ability to absorb short-term heavy grazing, sensitivity to stocking rate, and portion of ranch committed to a structured grazing system—all interact to characterize a grazing system's compatibility with a given long-term brush management strategy.

Posttreatment grazing strategies are immediate, long-term, or intermittent. Immediate grazing strategies generally are those adjustments required after installation of a brush control procedure. The primary reason for deferment after treatment is to allow established forage plants to improve vigor and possibly to allow seedling establishment, depending on timing of the deferment. Immediate posttreatment deferment reduces grazing pressure on preferred species which might otherwise be overgrazed when made more accessible by brush removal.

Long-term strategies generally emphasize inducing an upward trend in plant succession which allows the proportion of more desirable herbaceous species to increase. Long-term effective grazing management is critical to a sustained economic response in animal production. Most of the established systemized grazing methods are designed with graze–rest sequences which promote improved composition of the forage stands (range condition trend). These systems normally use several herds and pastures, such as the three-herd:four-pasture system. New approaches, such as intensive single-herd:multi-pasture grazing systems, tend to differ somewhat in that their potential AU response can be altered by adjusting stocking rates, pasture numbers, and graze–rest sequences. Greater control is exerted over plant selectivity, as well as frequency and intensity of defoliation, by the grazer in these high-density systems (28). If judicious increases in stocking are made, range improvement is promoted with the single-herd:multi-pasture system. However, care must be exercised not to increase stocking rates to a point where management looses control and accelerates range degradation, thereby negating the positive effects of brush management.

Some deferments require temporary disruption of, or adjustment in, long-term grazing strategies to accommodate brush treatments. If, for example, a deferment exceeds the normal rest period for a specific

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[3]Some exceptions may occur with certain plant parts. For example, cattle do not generally select for honey mesquite leaves but will readily consume the seed pods.

pasture, options to management include altering the stocking rate or graze–rest sequences and absorbing the extra grazing on the remainder of the grazing system, using another pasture outside the system, supplemental feeding, and selling animals. There are obvious economic advantages to developing flexible long-term grazing management plans which do not require major reductions of stock numbers or major alterations in operational level activities of the entire ranch to accommodate a given brush management method.

When planning grazing and brush management simultaneously, it is critical that attention be given to those systems (brush and grazing) that are compatible. If the owner gives priority to brush management over planned grazing, then grazing management would be adjusted to fit the brush management plan in development of the overall management program. Selection of specific brush management and grazing systems is always tempered by firm or owner objectives, constraints, and preferences (see also Chapter 2).

Grazing Management Strategies

Grazing management systems may be categorized as one-herd: two-pastures; one-herd:multiple-pastures; or multiple-herds: multiple-pastures (Table 6-2). A one-herd:one-pasture strategy, called continuous grazing, is generally viewed as the least satisfactory approach to grazing management because there are no grazing deferments to allow forage to set seed or to reinstate vegetative vigor following top removal. If the range is overstocked for extended periods, damage to the vegetation can be expected. However, decisional deferments can be used effectively by skilled managers without relying on planned grazing systems. Stocker programs which move livestock on and off the range can be used to provide effective deferment periods.

One-herd:two-pasture systems offer some of the simplest approaches to planned grazing. Two pastures may be grazed in various sequences including 4 months on–4 months off or a graze–defer sequence of 3–6–3–3–6–3 months. The sequences are developed so that deferment occurs at different seasons each year. If both pastures are stocked properly, range condition improves more rapidly than it does under well-managed continuous grazing, and brush management is more easily integrated into the system. Brush management procedures, such as herbicide application, may be scheduled for the rest periods so that one pasture is treated each year (46). The longer deferment periods (i.e., 6 months or longer) are preferable because of the opportunity for extended rest following treatment.

One-herd:multiple-pasture systems may be developed with relatively few pastures (three to seven), but most recent interest has focused on systems using 8–16 pastures, referred to as intensive short-duration grazing

TABLE 6-2. Examples of common grazing systems applied to Texas rangelands

Logistic class	Functional class	Subclass	Herds (no.)	Pastures (no.)	Desirable graze–rest sequence*	Moves/yr (no.)
One-herd:one-pasture	Continuous		1	1	365g; 0r (d)	0
One-herd:two-pasture	Decisional		1	2	Unplanned	Varies
	Deferred rotation	African switchback	1	2	6g; 3r; 3g; 6r (m)	3
	" "	"4×4"	1	2	4g; 4r (m)	3
One-herd:multiple-pasture	Short-duration	Extensive (HILF)	1	5	21–30g; 84–130r (d)	11–17
	" "	"	1	6	18–30g; 90–150r (d)	12–20
	" "	"	1	7	15–21g; 90–126r (d)	17–24
	" "	"	1	8	13–18g; 91–131r (d)	19–28
	Short-duration	Intensive (SDG)†				
	" "	"	1	5	10–14g; 40–56r (d)	26–36
	" "	"	1	6	7–12g; 35–60r (d)	30–52
	" "	"	1	7	5–10g; 30–60r (d)	36–73
	" "	"	1	8	5–9g; 35–61r (d)	42–73
	" "	"	1	9-16	3–5g; 30–60r (d)	50–160
	" "	"	1	15-30	1–3g; 28–58r (d)	121–180
Multiple-herd: multiple-pasture	Deferred rotation	Moderate rainfall	2	3	6g; 3r (m)	4
	" "	Low rainfall	2	3	12g; 6r (m)	2
	" "	Merrill	3	4	12g; 4r (m)	3
	Decisional		>1	>2	Unplanned	Varies

*Letter designations: g = graze, r = rest, m = months, d = days.

†Rest periods up to 90 days may be necessary in more arid or fragile ecosystems.

systems (SDG). The more extensive high-intensity, low-frequency systems (HILF)(< eight pastures) have consistently resulted in range improvement. Systems with five to seven pastures seem to result in greatest range improvement over a 15-year planning horizon. When these systems were first implemented in the early 1970s, there were reports of reduced livestock performance and conception. The problems resulted from too-long grazing periods, forcing consumption of less desirable grasses, being followed by rest periods which allowed the forage to become rank with a high proportion of stems and dead leaves. Many of these problems have been overcome by reducing the graze periods to approximately 2 weeks followed by 3–4 months of rest. Treatment of pastures during the rest period not only ensures some grazing deferment following application of the brush management practice, it also spreads treatment costs over 2 or more years, depending on number of pastures in the system. This also allows more time for addition of livestock to take advantage of improved vegetation conditions than when several pastures are treated during the same year.

Intensive SDG systems involve extremely brief, intensive grazing periods (generally fewer than 7 days) followed by rest periods of 30–90 days. The speed of rotation is increased as growth rate of available forage increases. This system requires a greater understanding of plant growth patterns than do other grazing systems. High stock densities (heavy grazing pressure) for short grazing periods allow for better livestock distribution (43) and increased grazing efficiency (1,62). Depending on potential vegetation and management skills, greater levels of stocking could be considered when the system is initiated. Thus, these systems could allow the rancher to achieve increased production response earlier in the planning horizon. At this time, we can suggest only conservative increases in initial stocking rates (15–40 percent above recommended stocking rates) until the operator is familiar with the variables influencing successful management of these intensive systems. The initial increase in stocking depends largely on the degree of improved grazing distribution. Once all distribution problems have been corrected, range condition trends become more static as stocking levels are increased above stocking rates recommended in range site condition guides.

Because of the deferment periods throughout the year, SDG is highly amenable to integration with a number of brush management practices. The relatively large number of pastures in SDG systems allows flexibility in scheduling deferments following brush management treatments. In extreme cases, an entire pasture may be omitted from the system, to allow additional deferment, with little or no adjustment in the grazing scheme. As a rule of thumb, a pasture may be eliminated if it does not constitute more than 10 percent of the system's carrying capacity. Use of cartwheel fencing configurations, however, may create some brush management problems. For example, the short distances between fences may preclude herbicide application by fixed winged aircraft, and burning must be applied to relatively small paddocks rather than large, single units.

The three-herd:four-pasture or Merrill grazing system is a common multiple-herd:multiple-pasture system. This system schedules 12 months grazing followed by 4 months rest for each pasture. Although less flexible than SDG and HILF relative to integration of brush management into the grazing schedule, with appropriate modification the Merrill system is compatible with many range improvement practices. This is also true of the two-herd:three-pasture deferred rotation system.

Major improvements in range condition and livestock performance are often possible through use of grazing systems, but integration of grazing management with brush management where woody plants severely limit forage production offers potential for greater improvement than could be attained with either practice alone. Any deferment expedites the rate at which desirable forage species occupy the area cleared of woody plants; the deferments provided in a sound grazing management plan will allow progressive improvement over a number of years.

During the past 30 years, many grazing systems have evolved that can improve range condition over time and gradually improve livestock production. Most of these systems, however, were developed independently of brush management which, in turn, consisted of single treatments. Brush management and grazing management generally have been planned under different decision-making conditions, and many brush control applications are made without benefit of any grazing deferment schemes. Management simply moves livestock around the ranch to accommodate "a practice," and little consideration is given to sequenced grazing and the follow-up treatments that are integral parts of the Integrated Brush Management Systems approach.

After reviewing many of the alternative grazing systems and attempting to integrate common brush management procedures, it is apparent that successful brush management often requires modification of grazing systems. Consequently, under realistic conditions where a ranch has both grazing and brush management problems, concurrent planning is essential. Planning should focus on the general requirements for a given brush management system, including selection of the initial treatment, sequencing of follow-up treatments, and intermittent grazing strategies required for successful execution of follow-up treatments. Once these constraints are established, then the planning process begins. It is essential that all planning for the integration of brush management be completed in terms of goals that can be realistically achieved over the entire planning horizon (see Chapter 2). There-are many instances where the potential number of animal units cannot be attained because of a deferment requirement that would result in short-term excessive grazing in another pasture in the system or on the ranch. In this case, management may opt to assess the cost and benefits of changing to another grazing system which more effectively captures the forage response with additional livestock. This process also allows management to determine livestock requirements in advance of installing the brush management practice.

A Hypothetical Example

A suggested first step in the planning process is development of a working grazing management–brush management plan. As an example, such a plan was developed for a hypothetical 820-acre site with a one-herd:two-pasture deferred rotation grazing system. Vegetation is dominated by honey mesquite and mixed brush. Carrying capacity at initiation of the plan is 32 AU for the 820-acre area or 1 AU/26 acres.

Using the best technical information available, management has decided to employ a brush management plan consisting of aerial herbicide application followed by prescribed burning. The two pastures are of equal carrying capacity and size, and the application cost will be spread over 2 years by spraying one pasture each year. Treatment selected is equivalent to the efficacy of a mixture of 2,4,5-T + picloram each applied at 0.5 pound per acre of each herbicide.[4]

For planning purposes, it is assumed that the first prescribed burn should be applied in late winter or early spring after the third growing season following spraying, with subsequent burns scheduled, on the average, every fourth or fifth year thereafter.

The spray application is intended to reduce the brush canopy cover and allow forage release to increase carrying capacity. The prescribed burns should suppress growth of brush surviving the spray and promote the more desirable forages over the long term. Prescribed burning should also improve nutritional value of the forage stands for 3–6 months after burning (46).

Immediate and intermittent grazing strategies include the following:

1. Defer for at least 60–90 days following spraying to allow forage to respond without any damage to key forage species.
2. Defer to build fine fuel for prescribed burning. Since most burns will be scheduled for late January or early February, the fall growth peak of herbaceous vegetation will be used to build the fine fuel load. Thus, deferment from September through November will be required in the year before each scheduled burn.
3. Defer for 45–60 days following burning so that the desirable forage plants will develop sufficiently to withstand grazing.
4. Defer during hot, dry summer periods the growing season following burning. Although this deferment may not be necessary in all years, it should be considered in the overall plan. Since luxuriant vegetative cover on burned areas usually increases the water-use demand on the soil (73), grazing pressure in addition to summer stress can prove detrimental to the forage stand.

Once the general requirements of the grazing system–brush management approach have been determined, changes in long-term carrying capacity must be estimated. Considerations for developing response curves are discussed in Chapter 7. The following generalized responses were assumed for this example:

1. Grazing capacity will increase to 1 AU/22 acres for 1 year beginning in the fall following the spray.
2. During the second and third years following spraying, the carrying capacity will increase to 1 AU/16 acres.
3. Following burning, the carrying capacity will increase to an average of 1 AU/14.5 acres and will remain at that level.

Figure 6-1 depicts anticipated changes in carrying capacities and an approach to balancing grazing with expected forage response to treatment. Sequencing the spray applications is relatively simple because of the long deferment periods in the growing season following brush treatment. Some difficulties may occur in year 3, however, when the carrying capacities of the two pastures are different.

For example, pasture 1 could carry 60 AU during year 3. However, since it is scheduled for prescribed burning and pasture 2 must absorb the additional animals during the deferment period required for fuel development, the number of animal units was increased only to 51 rather than 60 to ensure that the deferment requirements for prescribed burning are met. The full response was realized in year 4 when pasture 1 had been burned and carrying capacities of the pastures were equalized.

Animal numbers are expected to stabilize in year 4 for the remainder of the planning horizon. However, the grazing–rest sequence is altered as necessary to meet the requirements for avoiding the summer stress period following burning and for fuel building to conduct subsequent burns.

This scenario was developed as an example of deferment schedules and actions required to accommodate deferment needs. Such requirements will certainly vary with specific objectives and brush management–grazing combinations unique to each ranch firm.

[4] In this case, the entire pastures are treated for the sake of simplicity. In many cases, partial treatment of the pastures should be considered. The specific herbicide combination was chosen for purposes of examples only.

Grazing/Brush Management Strategy Plan

RANCH Doe Bar 3

Owner/Mgr. J. Q. Doe

YEAR	PASTURE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1	1	16	16	16	16	Spray→	.defer...	...	...	32	32	32	32
	2	16	16	16	16	32	32	32	32	32	... defer	...	...
2	1	32	.....	defer	....	42	42	42	42	42	42	...defer	...
	2	.....	32	32	32	←Spray→	.....	defer	...	...	...42	42	42
3	1	.....	defer	.....	51	51	51	51	51	51	...Fuel	Building	...
	2	42	42	42	.....	.....	defer	.....	.....	.....	51	51	51
4	1	.....	BURN	.....	60	60	60	.....	defer	.....	60	60	60
	2	51	51	51	.....	defer	.....	60	60	60	...Fuel	Building	...
5	1	60	60	60	.....	defer	.....	60	60	.....	defer	.....	60
	2	.....	BURN	.....	60	60	60	...	...	60	60	60	...
6	1	60	60	.....	defer	.....	60	60	60	60	...Fuel	Building	...
	2	defer	.....	60	60	60	.....	defer	.....	...	60	60	60
7	1	.....	BURN	....	60	60	60	.....	defer	.....	60	60	60
	2	60	60	60	.....	defer	.....	60	60	60	...Fuel	Building	..
8	1	60	60	60	.....	defer	.....	60	60	.....	defer	.....	60
	2	....	BURN	.....	60	60	60	....defer..		60	60	60	.....
9	1	60	60	60	.....	.....	..defer	....	....	....	60	60	60
	2	....	defer	.....	60	60	60	60	60	60	.....	defer	.....
10	1	60	60	60	......	defer	.....	60	60	60	Fuel	Building	.....
	2	.....	defer	.....	60	60	60	.....	defer	.....	60	60	60
11	1	.....	BURN	.....	60	60	60	.....	defer	.....	60	60	60
	2	60	60	60	.....	defer	......	60	60	60	...Fuel	Building	...
12*	1	60	60	60	.....	defer	.....	60	60	.....	defer	.....	60
	2	.....	BURN	.....	60	60	60	...de	fer...	60	60	60	......

* Repeat year 9-12 sequence for remainder of planning horizon.

Figure 6-1. Hypothetical grazing-brush management strategy plan for a single-herd:two-pasture grazing system integra[ted] with a herbicide application phased in over 2 years. Monthly values are in animal units.

7

Technology Selection Based on Economic Criteria

J. R. Conner

Economic analysis of technically feasible brush management alternatives requires assessment of benefits and costs in monetary terms. These analyses, however, will be incomplete to the extent that some benefits and costs are nonmonetary in nature.

The first step in assessing benefits and costs is to estimate the resources (labor, equipment, time, chemicals, etc.) required to implement each alternative practice or program and the changes in annual productivity (pounds of beef or wool, number of deer, etc.) expected to result from the practice or program (see Chapter 2). The necessary information on resources required is usually readily available, and quantities can be specified in the description of the treatment. Changes in annual productivity, however, are not as easily predicted.

Production Response

The rate and extent of herbaceous production change depends on initial brush cover, site, species of brush, initial herbaceous stand composition and production, and many other factors (46). Although there are ways to measure effects of changes in brush cover on herbaceous production (58, 70), information allowing direct calculation of production responses to brush management is not generally available. Rather, values of relative control levels of brush (i.e., percentage killed) are presented without regard to herbage release, livestock carrying capacity, wildlife habitat, etc. Percentage killed is of little use to an economist who must have some measure of production response to treatment to estimate economic performance.

Most brush control research has been of relatively short duration—5 years or less. This severely constrains (if not eliminates) the feasibility of projecting responses through a realistic time frame. Planning periods used in the analysis of brush management alternatives are usually several years in length, since most brush management alternatives increase rangeland productivity for several years after their initiation. In general, the planning period should include the years after initiation of a practice for which an increase in productivity over the current level can be expected. Some brush control programs, however, will increase productivity indefinitely. In any case, the planning period should not extend beyond the time relevant to the ranch management goals. In practice, this usually results in planning periods of 8–20 years.

Although specific predictions of production responses to brush management usually are not available, many range scientists, Soil Conservation Service range conservationists, and ranchers have considerable experience in observing production responses. Whitson and Scifres (71) developed a system based on a generalized response curve of Workman et al. (72) for recovering by interview data to build comparative response curves. The response curve (Figure 7-1) represents the change over time in carrying capacity of a specific site or management unit resulting from a specific treatment or set of treatments. Their research was directed toward evaluating alternative treatments for which scientist and range conservationist had a broad base of experience; for example, use of 2,4,5-T to control honey mesquite. Given ample published data and practical experience, however, the method can be used to develop response curves for other technologies and situations (30).

The following estimates are needed to construct a response curve:

1. Pretreatment production of the site or management unit, indicated by point $\mathbf{P_O}$ on the hypothetical curve (Figure 7.1). If an entire management unit is to be evaluated, separate curves need to be developed by site and final analyses should be weighted by proportion of each site in the management unit. This information comes from the resource inventory used to assess production potential when developing an IBMS (see Chapter 2).

2. Expected treatment life (**TL**) defined as the length of time in years required for the production level to return to $\mathbf{P_O}$. The point at which the treatment effect is ex-

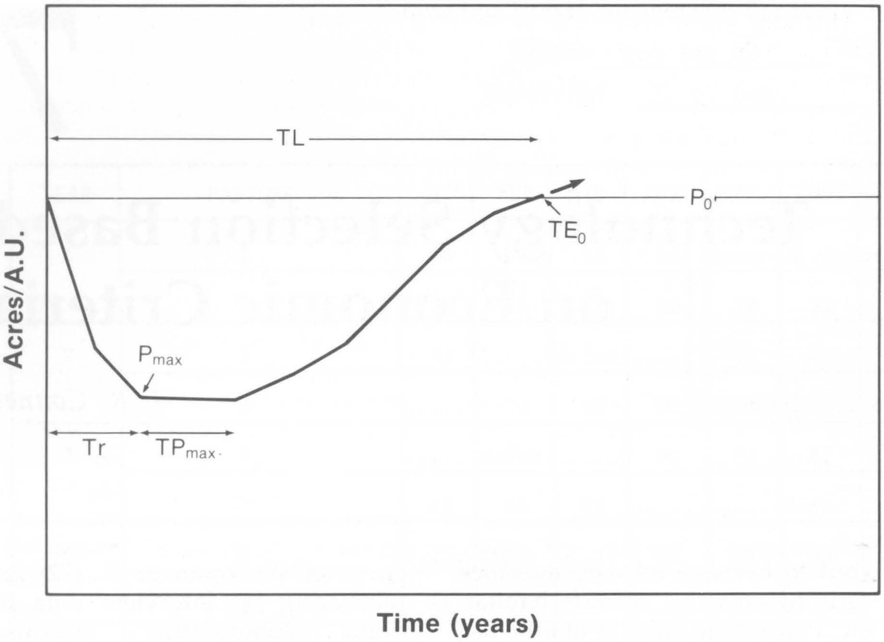

Figure 7-1. Components of a hypothetical response curve for economic evaluation of brush management alternatives.

hausted is indicated as $\mathbf{TE_O}$. In cases where the initial treatment effect is prolonged, or enhanced, by follow-up treatment, **TL** may be prolonged indefinitely. In such cases, the treatment effects (i.e., increased annual production levels) are projected through the last year of the planning period.

3. Maximum level of production ($\mathbf{P_{max}}$) that will be achieved by treatment for each major range site. The time that maximum production will be sustained is associated with the $\mathbf{P_{max}}$ value, $\mathbf{TP_{max}}$ on the hypothetical response curve.

4. The time required to reach $\mathbf{P_{max}}$ after application of a given treatment at $\mathbf{P_O}$. This is noted as **Tr** on the hypothetical response curve.

Several critical assumptions and considerations underlie development of response curves. As additional data are accrued, these assumptions can be replaced by quantitative information.

1. The level of production without treatment is usually assumed to remain constant throughout the planning profile. This assumption simplifies calculation of changes in annual production levels resulting from the treatments. However, if information is available from which to project annual production levels without treatment, then these projections may be used instead of the constant $\mathbf{P_O}$.

2. Precipitation is average (based on the long-term average) throughout the planning profile. Obviously, annual precipitation will fluctuate, sometimes radically, among years and among seasons within years. Modifications of the response curve development and economic assessment procedures to incorporate the effects of these variations on the economic feasibility of treatments are currently being researched (10). The current response curve procedure, however, assumes average rainfall.

3. Brush management does not interact with other resource management practices. As with rainfall, a radical change in other management practices (e.g., grazing management) may cause significant variation in performance of brush management treatments. Therefore, it is assumed that other management practices are held constant throughout the planning horizon.

Changes in carrying capacity cannot be converted directly into changes in pounds of beef produced. For example, in a cow–calf operation, effects of brush treatment on the herd's annual calving percentage and average calf weaning weight must also be estimated. Estimates of these changes can be obtained from producers with experience in managing herds under conditions similar to those expected from the treatment alternative. A detailed example of how these changes in annual productivity are estimated using response curves can be found in McBryde et al. (30).

The numerical response of game animals to brush treatments can be estimated with an adequate degree of accuracy. The tie between ecology and economics, however, is not as straightforward for wildlife as it is for livestock. The conversion from harvestable animals produced to income produced through the sale of hunting leases involves intangible recreational satisfactions that are to some degree independent of animal numbers. Furthermore, the marketing system is much less well organized, so there is a less orderly relationship between production and income.

Economic Analyses

Once the resource requirements and changes in annual productivity associated with each alternative are known, economic analyses of alternatives can proceed. Economic evaluation involves partial budgeting to estimate the change in cash flow resulting from application of the treatment for each year over the life of the treatment. These annual net cash flows (cash flow with treatment minus cash flow with no treatment) can then be discounted and summed for comparison with other improvement practices. (For examples see 16,30,70,71.)

Most costs associated with brush management are for products and services (such as chemical and aerial applications) for which market prices are readily available. Furthermore, the market prices are subject to little variation over a wide range of conditions and locations.

Accurate estimates of benefits

however, are generally much more difficult to obtain. Tangible benefits usually result from increases in salable products and (or) reductions in the cost of producing salable products. Salable products are generally limited to livestock, livestock products, and hunting leases. Market (sale) prices of livestock products for each year over the life of the project may be estimated using average market prices after adjusting for the effects of inflation and cyclical price variation.

Estimates of the impact of brush management alternatives on annual costs associated with livestock production must also be obtained. Cost reductions resulting from brush management practices may include reduced levels of supplemental feeding and reduced labor needed for handling livestock.

Hunting lease costs are associated with deer management (inventories, feeding, etc.), development and maintenance of hunt facilities (cabins, blinds, etc.), services rendered, insurance, and legal matters—all of which fluctuate with the intensity of game management. Each brush management alternative will have its own implications relative to abundance of game (see Chapter 5). Trends in numbers will follow the changing status of the managed brush as it contributes to habitat quality over time. Once adequate game populations are present, income appears to depend primarily on the sales effort. Benefits are estimated as expected changes in annual per acre lease rates.

Once the benefits and costs occurring each year over the life of each alternative are determined, they are discounted, to account for the time value of money (i.e., the interest that could be earned if the money were invested in a savings account) and summed to indicate the relative economic feasibility of each alternative.

Example

Two brush management programs for rangeland in South Texas are evaluated for a hypothetical 1,000-acre pasture, largely characterized by a sandy loam range site, with mixed brush forming a canopy cover of approximately 50 percent. The brush cover is advanced to the point where grazing by cattle at "proper-use" stocking rates would not result in a change in annual carrying capacity over the next 10–15 years.

The two alternatives considered

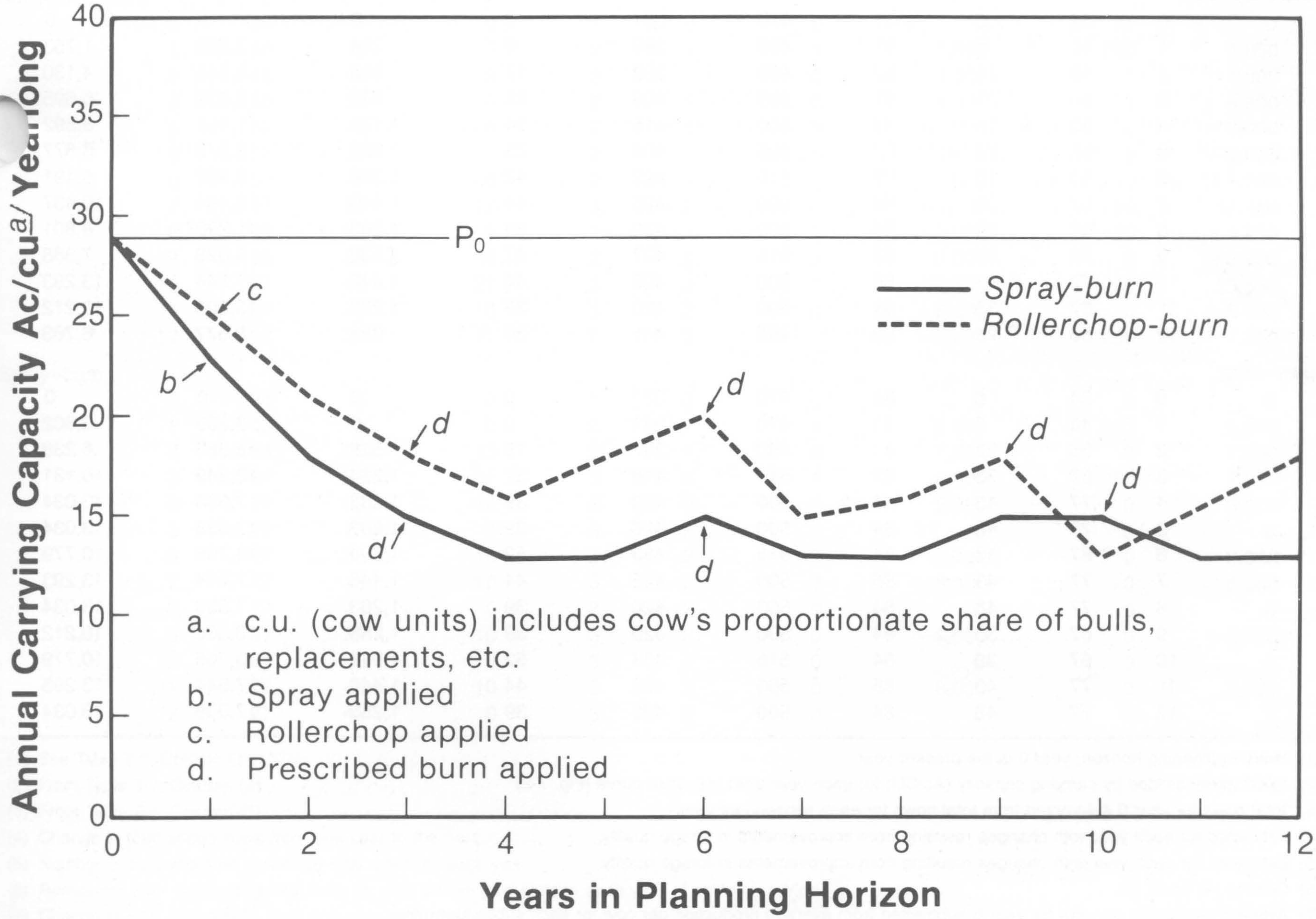

Figure 7-2. Carrying capacity projections for two treatments used in a hypothetical case example illustrating development of an integrated brush management system.

technically feasible are 1) aerial application of the effective equivalent of 1 pound per acre of 2,4, 5-T + picloram (1:1) followed by periodic prescribed burning to suppress regrowth and 2) roller chopping followed by periodic prescribed burning. The changes in expected annual carrying capacity over a 12-year period following initiation of each of these programs are shown in Figure 7-2. The 12-year planning period was selected because it was assumed that the level of response achieved by year 12 would represent the level that could be maintained, with minor annual fluctuations, into perpetuity if the periodic prescribed burning were continued. In addition, 12 years should be sufficient to determine if the investments in the brush control practices would produce an acceptable rate of return.

Table 7-1 shows the annual sales increases resulting from each of the brush management programs. In addition to the changes in carrying capacity, these calculations require that annual weaning weights and weaning percentages for the herd be estimated for each year in the planning period for each program. These annual production levels are then used, along with estimated annual calf sales prices, to estimate the total gross cattle sales increases resulting from the programs.

Table 7-2 details the procedure for determining cattle investment costs necessary to utilize improved carrying capacity. In addition to normal culling, cattle and sometimes bulls must be bought or sold to adjust stocking rates to the changing carrying capacity. Determining these costs requires an estimation of the investment cost of each cow and bull.

Initial costs associated with each brush management program (exclusive of deferment costs) are calculated in Table 7-3. In this case, rollerchopping was estimated to cost $9.25 per acre and spraying $23.50 per acre. Prescribed burns were assumed to cost $6 per acre for

TABLE 7-1. Increased livestock production from range improvement practices (hypothetical case study)

	Year (1)	Total cows (2)	Total added cows (3)	Percent calf crop (4)	Average weaning weights (5)	Average production per cow (6)	Increased production per cow (7)	Increased sales weight from year 0 (8)	Sales weight from added cows (9)	Total gross sales increase (10)
Rollerchop–burn					-----------	-----------	lb	-----------	-----------	
	0	34	0	81	470	381	0	0	0	$ 0
	1	40	6	81	480	389	8	264	2,239	1,753
	2	48	14	82	485	398	17	555	5,345	4,130
	3	56	22	81	505	409	28	925	8,639	6,695
	4	62	28	83	500	415	34	1,120	11,155	8,592
	5	56	22	82	495	406	25	823	8,573	6,577
	6	50	16	82	515	422	42	1,358	6,487	5,491
	7	67	33	85	500	425	44	1,446	13,464	10,437
	8	62	28	84	500	420	39	1,283	11,290	8,801
	9	56	22	83	515	427	47	1,526	9,028	7,388
	10	77	43	85	500	425	44	1,446	17,544	13,293
	11	67	33	84	500	420	39	1,283	13,306	10,212
	12	56	22	83	495	411	30	984	8,677	6,763
Spray–burn										
	0	34	0	81	470	381	0	0	0	0
	1	43	9	81	470	381	0	0	3,289	2,302
	2	56	22	81	490	397	16	529	8,383	6,238
	3	67	33	82	510	418	37	1,224	13,249	10,131
	4	77	43	84	500	420	39	1,283	17,338	13,034
	5	77	43	84	500	420	39	1,283	17,338	13,034
	6	67	33	84	515	433	52	1,694	13,705	10,779
	7	77	43	85	500	425	44	1,446	17,544	13,293
	8	77	43	84	500	420	39	1,283	17,338	13,034
	9	67	33	84	500	420	39	1,283	13,306	10,212
	10	67	33	84	515	433	52	1,694	13,705	10,779
	11	77	43	85	500	425	44	1,446	17,544	13,293
	12	77	43	84	500	420	39	1,283	17,338	13,034

(1) Years in planning horizon; year 0 is the present year.
(2) 1,000 acres divided by carrying capacity (Ac/CU) for each year from response curve (Fig. 7-2)
(3) Total cows for year 0 subtracted from total cows for each subsequent year.
(4) Estimated for each year with changes resulting from improvements in forage quality.
(5) Estimated for each year with changes resulting from improvements in forage quality.
(6) Column (4) times (5).
(7) Average production per cow for year 0 subtracted from average production per cow for each subsequent year.
(8) Column (7) times total cows for year 0 times a "shrink" factor of 0.96.
(9) Column (3) times (6) times a "shrink" factor of 0.96.
(10) Column (8) plus (9) times estimated sales price, in dollars per pound, for weaned calves for each year ($0.70 in this example).

the first application and $3.25 per acre for subsequent applications.

If stocking rates are to increase as a result of the brush management programs, then the annual operating costs for cattle production must also increase. Determination of the increase in annual costs is illustrated in Table 7-4. Occasionally, brush management programs will reduce per cow annual variable costs; e.g., for supplemental feed or labor. In such cases, these reductions are used to offset cost increases resulting from increased cow numbers. In the two examples used here, no such cost savings were assumed.

In Table 7-5, Column (5), other reductions in revenue (e.g., reduced deer hunting revenues) or other increases in costs (e.g., grazing deferment costs) should be accounted for. This example includes additional costs of approximately $5.50 per animal unit month (AUM) associated with the grazing deferment required for the initial treatments and prescribed burns.

Table 7-5 details the change in revenue and costs for each year and the resulting net change in annual cash flow resulting from each program. These changes in annual cash flow are then discounted at the appropriate rate (10 percent in this example) to account for the opportunity cost of money over the planning period. The present value factor (see Appendix H) for each year is determined by the formula $1/(1+r)^n$, where **r** is the discount rate and **n** is the year. In this manner, the manager is indicating that an investment in brush management should earn him a return at least equal to the selected rate. This rate may be the cost in interest of borrowed money or the interest rate that his money could earn if invested in an alternative investment such as a savings account. If the accumulated net present value, including any salvage values, at the end of the planning period is zero, then the investment in the

TABLE 7-2. Investment required in added breeding animals (hypothetical case study)

	Year (1)	Total cows (2)	Total added cows (3)	Added cows purchased/ sold (4)	Total bulls (5)	Total added bulls (6)	Added bulls purchased/ sold (7)	Investment in added cows (8)	Investment in added bulls (9)	Total added investment (10)
Rollerchop–burn										
	0	34	0	0	1	0	0	$ 0	$ 0	$ 0
	1	40	6	6	2	1	1	3,600	1,250	4,850
	2	48	14	8	2	1	0	4,800	0	4,800
	3	56	22	8	2	1	0	4,800	0	4,800
	4	62	28	6	2	1	0	3,600	0	3,600
	5	56	22	−6	2	1	0	−3,600	0	−3,600
	6	50	16	−6	2	1	0	−3,600	0	−3,600
	7	67	33	17	3	2	1	10,200	1,250	11,450
	8	62	28	−5	2	1	−1	−3,000	−1,250	−4,250
	9	56	22	−6	2	1	0	−3,600	0	−3,600
	10	77	43	21	3	2	1	12,600	1,250	13,850
	11	67	33	−10	3	2	0	−6,000	0	−6,000
	12	56	22	−11	2	1	−1	−6,600	−1,250	−7,850
Spray–burn										
	0	34	0	0	1	0	0	0	0	0
	1	43	9	9	2	1	1	5,400	1,250	6,650
	2	56	22	13	2	1	0	7,800	0	7,800
	3	67	33	11	3	2	1	6,600	1,250	7,850
	4	77	43	10	3	2	0	6,000	0	6,000
	5	77	43	0	3	2	0	0	0	0
	6	67	33	−10	3	2	0	−6,000	0	−6,000
	7	77	43	10	3	2	0	6,000	0	6,000
	8	77	43	0	3	2	0	0	0	0
	9	67	33	−10	3	2	0	−6,000	0	−6,000
	10	67	33	0	3	2	0	0	0	0
	11	77	43	10	3	2	0	6,000	0	6,000
	12	77	43	0	3	2	0	0	0	0

(1) See Table 7-1, Column (1).
(2) From Table 7-1, Column (2).
(3) From Table 7-1, Column (3).
(4) Change in total added cows from one year to the next.
(5) Number of bulls required to service total cows for each year.
(6) Remainder after subtracting total bulls for year 0 from total bulls in each year of planning period.
(7) Change in total added bulls from one year to the next.
(8) Column (4) times investment price ($600) per cow for each year.
(9) Column (7) times investment price ($1,250) per bull for each year.
(10) Column (8) plus (9).

brush management program is estimated to earn a rate of return equal to the discount rate specified; if negative, then the estimated rate of return is less than the specified discount rate. In both examples used here, the accumulated net present values are negative; thus, both investments are estimated to earn less than the specified 10 percent discount rate.

The internal rate of return is the discount rate which will result in an accumulated net present value of exactly zero. Thus, it is the true rate of return that an investment in each brush management program is expected to earn. In this example, we see that the investment in the spray–burn program is expected to earn an average 7.47 percent rate of return, or 7.47 cents per year per dollar invested. The roller chop–burn program, however, is expected to earn a 9.54 percent rate of return.

This information can be used to decide which brush management practice to select or whether the expected rate of return from any of the alternatives is sufficiently large to warrant the investment.

TABLE 7-3. Investment required for brush control and (or) seeding (hypothetical case study)

	Year (1)	Acres treated (2)	Cost per acre (3)	Total cost (4)
Rollerchop–burn				
	0	0	$ 0	$ 0
	1	1,000	9.25	9,250
	2	0	0	0
	3	1,000	6.00	6,000
	4	0	0	0
	5	0	0	0
	6	1,000	3.25	3,250
	7	0	0	0
	8	0	0	0
	9	1,000	3.25	3,250
	10	0	0	0
	11	0	0	0
	12	0	0	0
Spray–burn				
	0	0	0	0
	1	1,000	23.50	23,500
	2	0	0	0
	3	1,000	6.00	6,000
	4	0	0	0
	5	0	0	0
	6	1,000	3.25	3,250
	7	0	0	0
	8	0	0	0
	9	0	0	0
	10	1,000	3.25	3,250
	11	0	0	0
	12	0	0	0

(1) See Table 7-1, Column (1).
(2) Number of acres receiving treatment in each year.
(3) Cost of treatment per acre.
(4) Column (2) times (3).

TABLE 7-4. Added annual variable costs from range improvement practice (hypothetical case study)

	Year (1)	Total cows (2)	Total added cows (3)	Variable costs per cow (4)	Total var. costs for added cows (5)	Var. cost savings from present herd (6)	Total incr. livestock costs (7)
Rollerchop–burn	0	34	0	$125	$ 0	$0	$ 0
	1	40	6	125	750	0	750
	2	48	14	125	1,750	0	1,750
	3	56	22	125	2,750	0	2,750
	4	62	28	125	3,500	0	3,500
	5	56	22	125	2,750	0	2,750
	6	50	16	125	2,000	0	2,000
	7	67	33	125	4,125	0	4,125
	8	62	28	125	3,500	0	3,500
	9	56	22	125	2,750	0	2,750
	10	77	43	125	5,375	0	5,375
	11	67	33	125	4,125	0	4,125
	12	56	22	125	2,750	0	2,750
Spray–burn	0	34	0	$125	0	0	0
	1	43	9	125	1,125	0	1,125
	2	56	22	125	2,750	0	2,750
	3	67	33	125	4,125	0	4,125
	4	77	43	125	5,375	0	5,375
	5	77	43	125	5,375	0	5,375
	6	67	33	125	4,125	0	4,125
	7	77	43	125	5,375	0	5,375
	8	77	43	125	5,375	0	5,375
	9	67	33	125	4,125	0	4,125
	10	67	33	125	4,125	0	4,125
	11	77	43	125	5,375	0	5,375
	12	77	43	125	5,375	0	5,375

(1) See Table 7-1, Column (1).
(2) From Table 7-1, Column (2).
(3) From Table 7-1, Column (3).
(4) Estimated annual variable costs per cow for each year in the planning period. If treatment changes annual variable (operating) costs per cow, then costs as changed should be shown.
(5) Column (3) times (4).
(6) Product of total cows in year 0 and remainder after variable costs per cow in year 0 are subtracted from variable costs per cow for each subsequent year.
(7) Column (5) plus (6).

TABLE 7-5. Net present value and internal rate of return from adoption of range improvement practices (hypothetical case study)

Year (1)	Total gross sale increase (2)	Total added investment (3)	Total incr. var. lvstk. costs (4)	Other reduced revenues (5)	Net cash flow (6)	Present value factors (7)	Annual present value (8)	Accum. present value (9)
Rollerchop–burn								
0	$ 0	$ 0	$ 0	$ 0	$ 0	1.000	$ 0	$ 0
1	1,753	14,100	750	700	-13,797	0.909	-12,543	-12,543
2	4,130	4,800	1,750	800	-3,220	0.826	-2,661	-15,204
3	6,695	10,000	2,750	700	-7,555	0.751	-5,676	-20,880
4	8,592	3,600	3,500	0	1,492	0.683	1,019	19,861
5	6,577	-3,600	2,750	900	6,527	0.621	4,053	-15,80[illegible]
6	5,491	-350	2,000	800	3,041	0.564	1,717	-14,09[illegible]
7	10,437	11,450	4,125	0	-5,138	0.513	-2,637	-16,729
8	8,801	-4,250	3,500	1,000	8,551	0.467	3,989	-12,740
9	7,388	-350	2,750	900	4,088	0.424	1,734	-11,006
10	13,293	13,850	5,375	0	-5,932	0.386	-2,287	-13,293
11	10,212	-6,000	4,125	0	12,087	0.350	4,236	-9,056
12	6,763	-7,850	2,750	0	11,863	0.319	3,780	-5,277
Salvage value*					14,450	0.319	4,604	-673
Internal rate of return† 9.54%								
Spray–burn								
0	0	0	0	0	0	1.000	0	0
1	2,302	30,150	1,125	700	-29,673	0.909	-26,975	-26,975
2	6,238	7,800	2,750	900	-5,212	0.826	-4,308	-31,283
3	10,131	13,850	4,125	1,100	-8,944	0.751	-6,720	-38,002
4	13,034	6,000	5,375	0	1,659	0.683	1,133	-36,869
5	13,034	0	5,375	1,300	6,359	0.621	3,949	-32,921
6	10,779	-2,750	4,125	1,100	8,304	0.564	4,687	-28,233
7	13,293	6,000	5,375	0	1,918	0.513	984	-27,249
8	13,034	0	5,375	0	7,659	0.467	3,573	-23,676
9	10,212	-6,000	4,125	1,100	10,987	0.424	4,659	-19,016
10	10,779	3,250	4,125	1,300	2,104	0.386	811	-18,205
11	13,293	6,000	5,375	0	1,918	0.350	672	-17,533
12	13,034	0	5,375	0	7,659	0.319	2,440	-15,092
Salvage value*					28,300	0.319	9,017	-6,075
Internal rate of return + 7.47%								

(1) See Table 7-1, Column (1).
(2) From Table 7-1, Column (10).
(3) Table 7-2, Column (10), plus Table 7-3, Column (4) for each year.
(4) From Table 7-4, Column (7).
(5) Changes in costs or revenue resulting from treatments, such as hunting revenue or, as in this example, costs associated with pasture deferments.
(6) Remainder after subtracting Columns (3), (4), and (5) from Column (2) for each year.
(7) Present value factor for the selected discount rate for each year. (See Appendix H.)
(8) Column (7) times (6).
(9) Accumulated sum of annual present values for each year from Column ([illegible]

*Salvage value is the value of investments made during planning period at the end of planning period.

†Internal rate of return is the discount rate which would result in an accumulated net present value of exactly zero at the end of the planning period.

8

Applying and Evaluating IBMS

W. T. Hamilton

Implementing and monitoring IBMS require careful coordination of planning elements with actual applications and follow-up evaluations of treatments. Implementing includes specifications and layout of treatments, equipment, timing and sequence of treatments, management responsiveness, and record-keeping functions involved with the application of primary or contingency IBMS plans. Monitoring involves measuring treatment responses in the categories of livestock, wildlife and recreation, vegetation, labor and management, and economics. Both activities require a high level of communication between all persons involved in the IBMS process.

IMPLEMENTATION

Proper procedures for implementing IBMS involve adherence to specifications developed for treatments, design or layout of practices, equipment requirements, and application techniques. Specifications should address each of these areas, and personnel responsible for implementing them should be aware that ultimate success depends on following the plans. For example, specifications for a herbicide treatment would include the herbicide or combinations of herbicides, formulations, rates, mixing requirements, and additives (surfactants, etc.). Layout would require the transfer of designed treatment configurations from scale maps to actual physical delineations of these same areas on the land (Figure 8-1). This can be critical with respect to preservation of wildlife habitat and effectiveness of treatments with relation to susceptibility of plant species.

Equipment

Equipment used for treatments must be capable of installing practices according to specifications. Machinery or aircraft that is underpowered or inadequately equipped to accomplish desired results must be avoided. Moreover, specific application specifications, such as swath width and altitude for aerial spraying or speed and depth for mechanical treatments, are often keys to ultimate success. Ranch managers must insure that adequate equipment is available to implement treatments in accordance with specifications and at the appropriate time. It is possible that ranch-owned equipment is suitable for some treatments; however, contracted equipment is usually needed. This means that firm arrangements must be made with contractors for the necessary equipment and skilled operators at the scheduled time.

Timing and sequence

Timing and sequence of treatments is also a critical part of IBMS implementation. Many biological responses to treatments are highly correlated to season of application and even to specific timing within a season or a day because of temperature or humidity requirements (46) (see also Chapter 3). Some practices within IBMS treatment sets depend on timing of other management practices and installation of facilities. For example, prescribed burning frequently requires pretreatment and posttreatment grazing deferments which in turn may require extra fencing and water facilities (see also Chapter 6).

As with all plans, timing and sequence of secondary IBMS practices are best related to actual responses obtained from initial treatment and the times at which they occur. Plans projecting into the future are affected by many variables, such as weather, which cannot be accurately predicted. Therefore, the order and timeliness of follow-up treatments must depend on reassessment and, often, a redesign of maintenance requirements. This is a part of the feedback system inherent to IBMS. Maintenance treatments have the same requirements for coordination with grazing and wildlife management as do initial applications (see Chapter 6).

An example of timing and sequence could go like this: A planned treatment set consists of two-way chaining followed by periodic maintenance burns beginning the second year after initial treatment and every fourth year thereafter. However, the initial treatment does not release adequate fine fuel loads and woody plant regrowth is more rapid than anticipated, so the sequence is adjusted to include stacking before burning.

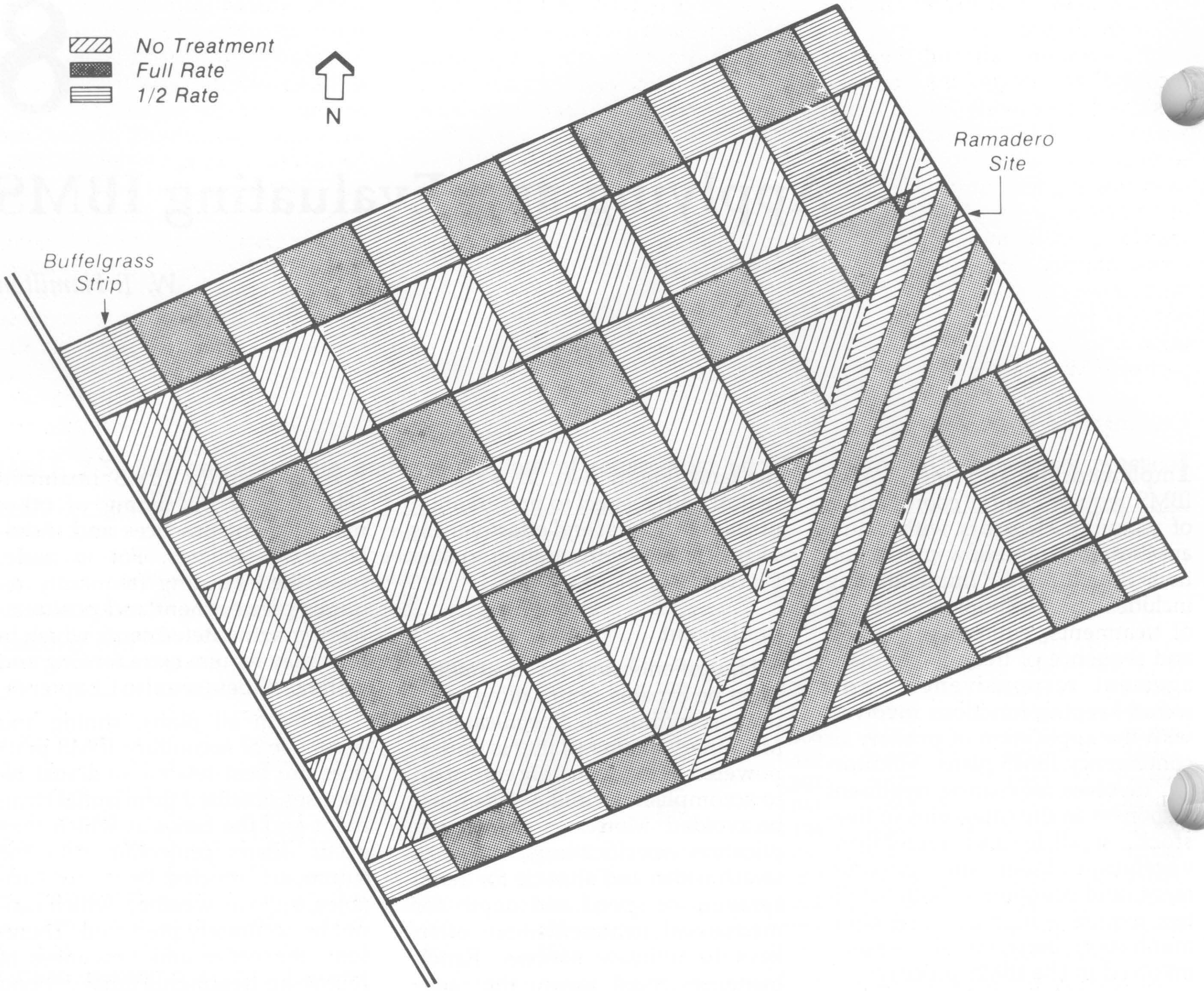

Figure 8-1. Actual layout of herbicide application in a variable rate pattern designed to meet management requirements for an integrated brush management system in South Texas.

Management responsiveness

A significant part of IBMS implementation is management responsiveness to changes resulting from treatment applications. Projected benefits must be realized in order for the enterprise to profit from them. This often requires looking ahead on response curves and planning needed adjustments, such as additional livestock to take advantage of increased forage production. That brush treatments result in increased forage production is often documented, but these increases must be converted through animals into productive assets if the anticipated economic benefits are to be realized. Such timely adjustments in livestock numbers are not always easy to accomplish, but planning based on projected responses can help.

Responsiveness by managers to required livestock movements is also a key IBMS element. For example, deferment of seeded areas during emergence and stand establishment may well determine the success of the treatment. Burned areas also require timely deferments—before burning to build fine fuel and after to allow regrowth of forage. Many such livestock movements cannot wait; therefore, willingness and ability to make and implement the necessary decisions must be part of the manager's commitment to IBMS.

Record-keeping requirements

Implementation also requires accurate records of costs and events occurring during treatment applications. This allows comparison of estimated costs with actual data to assess IBMS performance. When combined with documentation of benefits in the posttreatment monitoring process, these data provide the basis for an economic assessment of costs and returns (see Chapter 7). This in turn can be fed back into the system to assist in development of technical alternative sets (Figure 2-1).

Management should keep a record of any deviations from the designed treatment applications and of any variables, such as environmental factors, that may assist in explaining responses. This kind of information may be useful in matching treatments with specific conditions not documented by previous research. Some cost and benefit data is easily overlooked if an effort is not made to consider it a part of IBMS implementation.

Contingency plans

In spite of an excellent plan and specific designs for treatment applications, the influence of weather or other factors can force a decision to postpone or abandon a portion of an IBMS treatment set. This is particularly true of treatments that are tied to a specific season, such as foliar herbicide applications and prescribed burning, and require a rather precise set of weather-related conditions. In some instances, the enterprise financial commitment to other parts of a system which are already applied may make it undesirable to simply postpone a treatment for an entire year. In these circumstances, contingency plans can be implemented. To be effective, however, they must already be in existence and must have had the same level of advance preparation as the primary plan. Decision makers must have decided in advance that if the primary treatment cannot be applied, the contingency plan will be implemented. Such a contingency plan will be a "second best," technically feasible alternative that has been through economic analysis in the planning process and compares favorably to the primary alternative. This early decision on the contingency plan allows time for development of detailed implementation specifications, preparation of maps for layout, and location of available equipment before they are needed.

In summary, IBMS implementation is a coordinated process that puts into existence those treatment sets deemed most appropriate by enterprise decision makers to meet objectives. It encompasses the entire integrated plan, including brush management, grazing management, wildlife, and other areas of consideration. Therefore, adherence to plans, even if they are contingency plans, is essential for success. That no one element can be efficient without the whole is a basic premise that distinguishes IBMS from single practice applications.

Monitoring

If IBMS is to fulfill its potential, it must accept feedback from implementation to evaluate progress and assess the effectiveness of applied treatments. Such assessments in turn provide the basis for adjustments to treatment sets and may even influence modification of initial objectives. Feedback is information that documents IBMS performance by monitoring posttreatment responses. While monitoring is essentially an intensified posttreatment data-gathering and record-keeping function, it is an integrated part of total system implementation. Microcomputer software is currently being developed that should facilitate such ranch record keeping (33).

Many responses which can be monitored will contribute significantly to IBMS assessment. Some of these are documented by routine operating records common to the majority of ranch businesses, while others are detailed evaluations that require expertise and equipment unavailable to most ranch operations. Therefore, the IBMS monitoring process is best accomplished with a combination of ranch personnel and outside technical advisers, such as the Soil Conservation Service or private consultants. It is quite probable that such personnel would be involved in the entire IBMS process and that system monitoring would be an accepted part of their function.

Livestock responses

Livestock responses can be measured from accurate, timely records kept during routine ranch operations. Monitoring should encompass all livestock activities associated with the management units involved in IBMS and predetermined to be important to performance assessment. It may also be desirable to have similar information on portions of the same ranch outside of the IBMS units.

Data should include such items as livestock in–out dates, number of head, and kind and class of animals. Additionally, information is needed on weaning weights and stocker in–out weights. Cow weights are usually also desirable. In the case of fiber-producing animals, records must be kept on wool and mohair yields. Records should also be kept on conception rates of breeding females, breeding dates, and number of breeding males used. Death losses, veterinary and medicine costs, and other health-related activities should be documented, as should supplemental feeding (dates, feed components, amounts fed, and costs). Sales income attributed to the IBMS units must be identified, as well as any costs associated with the sales.

Measurements of these and other system responses allow economic assessment of changes resulting from implementation of IBMS. They form the basis for comparison of actual product yields to those projected on the response curves during the planning process (Figure 7.1). Even if economic results deviate from projections, because of fluctuating markets and prices within a given time frame, production records will provide a basis for evaluating system performance in bringing about desired biological changes.

Wildlife, recreation responses

Monitoring responses of wildlife and recreation resources requires the same attention to record keeping as monitoring livestock responses. Surveys to assess changes occurring after treatment application should become an accepted part of the monitoring process. Since wildlife inventory and the compilation of specific measurements require expertise not associated with many ranch operations, technical assistance for this part of IBMS is usually required. Surveys normally estimate animal density, herd performance (as measured in terms of sex/age ratios, age composition, etc.), and individual animal performance (age, body weight, antler development, etc.). Monitoring should be done annually in association with the hunt. Standard prehunt censuses in addition to check stations during the hunt usually provide the desired information.

Lease income for hunting, fishing, and recreation rights should be documented as well as associated expenses. It is also important to measure hunter acceptance and success in the system, as this relates to future income potential and the ability to match harvest requirements with management's objectives. Experience has shown that monitoring wildlife responses to treatment is tedious and intensive and that it requires a high level of commitment and cooperation to gather the desired information.

Vegetation responses

Monitoring vegetation changes is an obvious part of IBMS, since modifying the pretreatment woody–herbaceous plant composition is a basic goal of the system. While responses of vegetation to IBMS treatment sets is measured in part by animal products the area yields, important trends in vegetation to meet the desired mix of kinds, density, and stature of plants must be documented to provide information on projected yields and maintenance treatments. Vegetation monitoring produces data to assess the degree of change in targeted and secondary woody species and subsequent changes in herbaceous vegetation. Knowing where the system is at various times in relation to predicted responses is fundamental to the IBMS feedback process. Thus, monitoring allows specific modifications that make IBMS a systems approach to range–wildlife–livestock management.

Vegetation parameters commonly monitored include relative composition of species, herbage production and utilization, and woody plant characteristics, such as canopy cover, density, and height (see Chapter 2 for techniques). Data are used to assess stocking rates, sequence and timing of maintenance treatments, and other factors, such as the development of wildlife habitat requirements. Precipitation records are also an integral part of vegetation monitoring because they assist in correlating posttreatment rainfall with treatment performance (10).

Labor and management

Brush and grazing management treatments implemented as a part of IBMS can affect labor and management requirements on the ranch (41). Such influences range from possible reductions in labor—because of the greater ease in working cattle as brush is reduced, or more efficient use of labor in one-herd:multiple-pasture grazing systems—to an increase in managerial requirements as systems become more sophisticated. Since labor and management costs are affected by IBMS, they should be monitored the same as any other posttreatment change.

Economics

Finally, all monitoring activities should feed both biological and cost/income data into an economic assessment to calculate actual versus projected returns from the systems, as discussed in Chapter 7. This is the end result of the planning–implementation–monitoring process. While final economic analyses may be different from those in initial plans, the system has provided, through monitoring, for identification of factors which caused these deviations and for needed reassessment of the plans and implementation.

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Scientific Names of Plants and Animals Mentioned in Text

Common Name	Scientific Name
Woody Plants and Succulents	
Agarito	*Berberis trifoliolata*
Allthorn	*Koeberlina spinosa*
American beautyberry	*Callicarpa americana*
Ashe juniper	*Juniperus ashei*
Baccharis	see willow baccharis
Beautyberry	see American beautyberry
Berlandier wolfberry	*Lycium berlandieri*
Blackbrush acacia	*Acacia rigidula*
Blackjack oak	*Quercus marilandica*
Bluewood condalia	*Condalia obovata*
Buckbrush	*Symphoricarpos orbiculatus*
Cactus	see pricklypear, cholla, tasajillo
Catclaw acacia	*Acacia greggii*
Catclaw mimosa	*Mimosa biuncifera*
Cenizo	*Leucophyllum frutescens*
Chinese tallow	*Sapium sebiferum*
Cholla	*Opuntia imbricata*
Creosotebush	*Larrea tridentata*
Eastern persimmon	*Diospyros virginiana*
Elms	*Ulmus spp.*
Greenbrier	*Smilax bona-nox*
Guajillo	*Acacia berlandieri*
Guayacan	*Porlieria angustifolia*
Hackberry	*Celtis spp.* see also netleaf hackberry, spiny hackberry
Hawthornes	*Crataegus spp.*
Hercules club pricklyash	*Zanthoxylum clava-herculis*
Honey locust	*Gleditsia triacanthos*
Honey mesquite	*Prosopis glandulosa var. glandulosa*
Huisache	*Acacia farnesiana*
Javelinabrush	*Microrhamnus ericoides*
Juniper	*Juniperus spp.* see also ashe juniper, redberry juniper
Leatherstem	*Jatropha dioica*
Lime pricklyash	*Zanthoxylum fagara*
Live oak	*Quercus virginiana*
Lotebush condalia	*Ziziphus obtusifolia*
Macartney rose	*Rosa bracteata*
Mesquite	*Prosopis spp.* see also honey mesquite
Mimosa	*Mimosa spp.* see also catclaw mimosa
Netleaf hackberry	*Celtis reticulata*
Persimmon	*Diospyros spp.* see also eastern persimmon, Texas persimmon
Post oak	*Quercus stellata*
Pricklypear	*Opuntia spp.*
Redberry juniper	*Juniperus pinchotii*
Sand shinnery oak	*Quercus havardii*
Saltcedar	*Tamarix gallica*
Spiny hackberry	*Celtis pallida*
Sumac	*Rhus aromatica*
Tarbush	*Flourensia divaricata*
Tasajillo	*Opuntia leptocaulis*
Texas colubrina	*Colubrina texensis*
Texas persimmon	*Diospyros texana*
Twisted acacia	*Acacia tortuosa*
Water oak	*Quercus nigra*
Whitebrush	*Aloysia lycioides*
Willow baccharis	*Baccharis salicina*
Winged elm	*Ulmus alata*
Yaupon	*Ilex vomitoria*
Grasses	
Buffelgrass	*Cenchrus ciliaris*
Texas wintergrass	*Stipa luecotricha*
Forbs and Subshrubs	
Croton	*Croton spp.*
Dayflower	*Commelina spp.*
Ragweed	*Ambrosia spp.*
Spiny aster	*Aster spinosus*
Sunflower	*Helianthus spp.*
Wildlife	
Bobwhite	*Colinus virginianus*
Javelina	*Tayassu tajacu*
Mourning dove	*Zenaida macroura*
Scaled (blue) quail	*Callipepla squamata*
Turkey	*Meleagris gallopavo*
White-tailed deer	*Odocoileus virginianus*
White-winged dove	*Zenaida asiatica*

Clay Loam Range Site Description

Land Resource Area Rio Grande Plain ____________________

Location ____________________

Date ____________________

1. TOPOGRAPHY AND ELEVATION: This site occurs on nearly level to gently sloping areas with slopes usually less than 3 percent.

2. SOILS:

   a. These soils are deep with a silty clay loam, clay loam or sandy clay loam surface and a clayey subsoil. Permeability of the subsoil is slow to moderate. The water holding capacity and production potential on this site are high.

   b. Some taxonomic units which characterize this site are:

      Garceno clay loam
      Moglia clay loam

   c. Specific site location:

      La Mesa Ranch,
      Pasture #24; along old Mines Road; 6 miles north of the Tick Force Station.

3. CLIMAX VEGETATION:

   a. The climax plant community is a semi-open grassland with scattered mesquite trees and woody shrubs. The dominant grass species a mid grasses. The site supports some climax forbs such as Engelmanndaisy, bundleflower and zexmenia.

RELATIVE PERCENTAGE

Grasses	90%	Woody	5%	Forbs	5%
Two & fourflower trichloris		Mesquite		Bundleflower	
		Whitebrush		Sensitivebriar	
Arizona cottontop	35	Lotebush		Dalea spp.	
Pinhole bluestem	10	Condalia		Orange zexmenia	5
		Spiny hackberry		Bushsunflower	
Plains bristlegrass	10	Cacti spp.		Annual forbs	
Buffalograss		Texas Colubrina			
Curlymesquite	10	Wolfberry			
Pink pappusgrass	20	Vine Ephedra			
		Desert yaupon			
Perennial threeawn		Guayacan			
Texas bristlegrass	5	Knife-leaf condalia			
Red grama	T	Green condalia			
		Guajillo			
		Blackbrush			
		Creosotebush			
		Narrowleaf forestiera	5		

   b. As retrogression occurs, mesquite, whitebrush and other mixed brush form a dense canopy. Common invaders to the site are red grama, purple three-awn, leatherstem, tumblegrass, huisache, ragweed, and tasajillo.

      In a denuded state, the bare ground crusts over—retarding rainfall intake as well as seedling growth.

   c. Approximate total annual yield of this site in excellent condition ranges from 2,000 pounds per acre in poor years to 4,000 pounds per acre of air-dry vegetation in good years.

4. WILDLIFE NATIVE TO THE SITE: This site provides habitat needs of deer, javelina, quail, and whitewing and mourning dove. The woody plants, forbs, and grasses on this site provide excellent cover, browse, mast, and seeds for game animals and birds.

FROM: USDA, Soil Conservation Service, Area 25, Laredo, Texas, Tech. Guide, Sect. II-E.

5. GUIDE TO INITIAL STOCKING RATE:

a.

Condition class	Percent climax vegetation	Ac/AU/yearlong
Excellent	76-100	15-18
Good	51-75	18-22
Fair	26-50	20-25
Poor	0-25	25

b.

Introduced species	Percent of the area established			
	100-76	75-51	50-26	25-0
Introduced grasses	13-16	15-20	18-25	25

RELATIVE FORAGE QUALITY OF SPECIES*

Primary	Secondary	Low Value
FOR CATTLE		
Fourflower trichloris	Buffalograss	Perennial threeawn
Arizona cottontop	Curlymesquite	Mesquite
Sideoats grama	Pink pappusgrass	Condalias
Plains and spike bristlegrass	Orange zexmenia	Cacti sp.
Englemanndaisy	Sensitivebriar	Blackbrush
Bundleflower	Spiny hackberry	Whitebrush
Daleas		Most annual forbs
Mexican sagewort		
Vine ephedra		
Pinhole bluestem		
Bushsunflower		
FOR DEER		
Hackberry	Blackbrush	Mesquite
Englemanndaisy	Vine-mesquite	Condalia sp.
Mexican sagewort	Texas wintergrass	Whitebrush
Bundleflower	Bristlegrass	Texas colubrina
Sensitivebriar	Cacti fruit	
Spiny hackberry	Orange zexmenia	
Scribner's panicum		
Vine ephedra		
Dalea sp.		
Most annual forbs		
Guayacan		
Bushsunflower		
FOR JAVELINA		
Hackberry fruit	Most grasses	Most annual forbs
Cacti roots and fruit	Whitebrush roots	Condalia sp.
Yucca roots	Blackbrush	Mesquite
Mesquite beans	Bundleflower	
Fleshy roots		
Tubers		
FOR QUAIL AND DOVE (whitewing and mourning)		
Western ragweed seed	Perennial broomweed seed	Most woody plants
Croton seed	Sideoats grama seed	
Bundleflower seed	Tasajillo fruit	
Sensitivebriar seed	Mesquite beans	
Panicum seed		
Bristlegrass seed		
Hackberry fruit		
Sunflower seed		

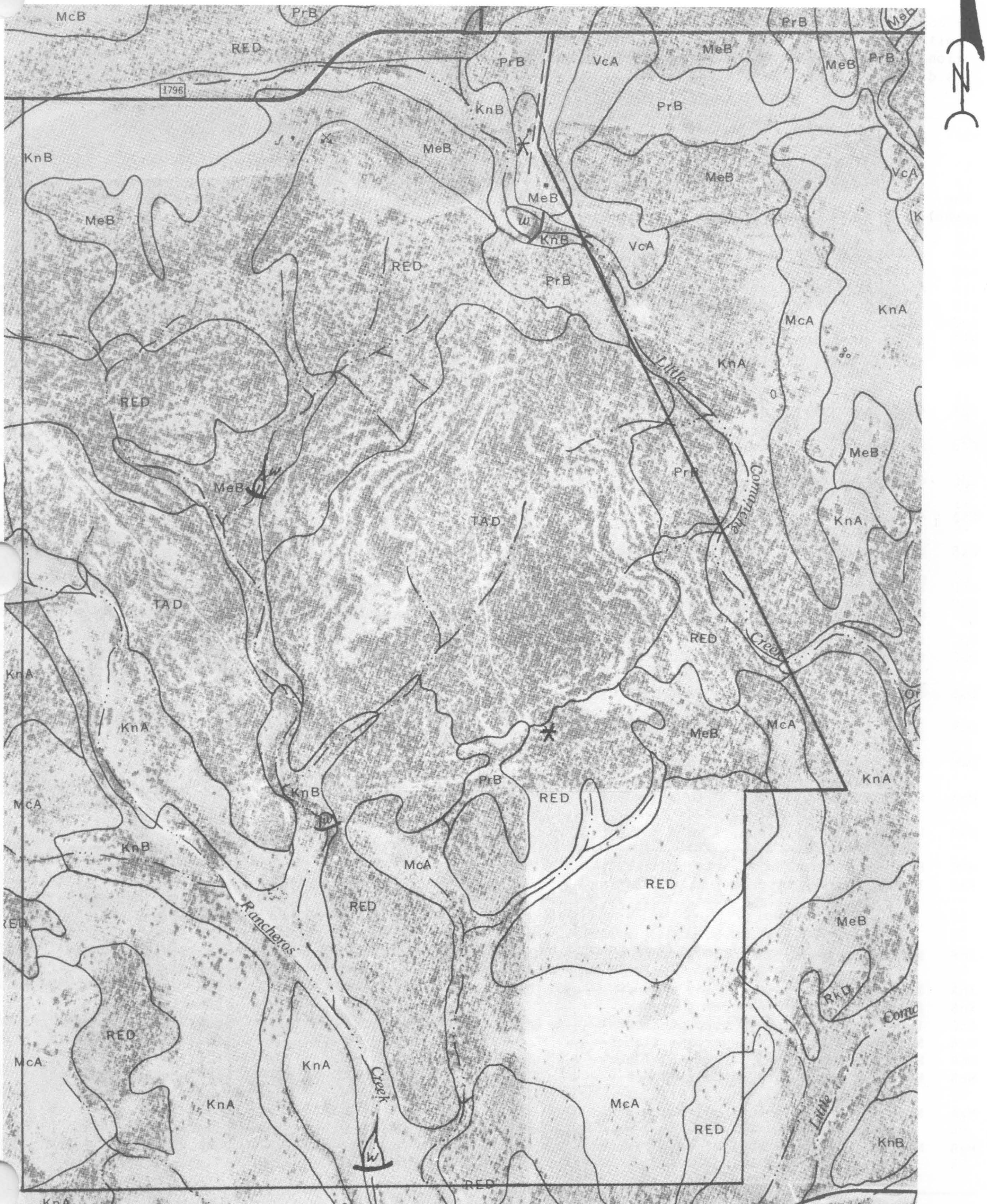
*Definitions of terms and an explanation of interpretations is given on a separate page which is attached or submitted with each group of range site descriptions.

Appendix C

Forage Inventory
Original Ranch

Pasture Number	Range Site	Range Condition	Acres	Stocking Rate AC/AUY	AUY	AUM
1	Clay Loam	Good	155	18	8.61	103.3
	Shallow	Fair	59	23	2.56	30.7
	Adobe	Fair	21	24	.88	10.5
	Subtotal Pasture No. 1		235		12.05	144.5
2	Clay Loam	Fair	132	21	6.29	75.4
	Shallow	Fair	78	23	3.39	40.7
	Adobe	Fair	38	24	1.58	19.0
	Subtotal Pasture No. 2		248		11.26	135.1
3	Clay Loam	Fair	87	21	4.14	49.7
	Shallow	Fair	395	23	17.17	206.1
	Adobe	Fair	747	24	31.13	373.5
	Low Stony Hill	Fair	538	21	25.62	307.4
	Subtotal Pasture No. 3		1767		78.06	936.7
(Continue for all management units)						
	Total Ranch		6008		289.44	3473.3

SOIL MAP

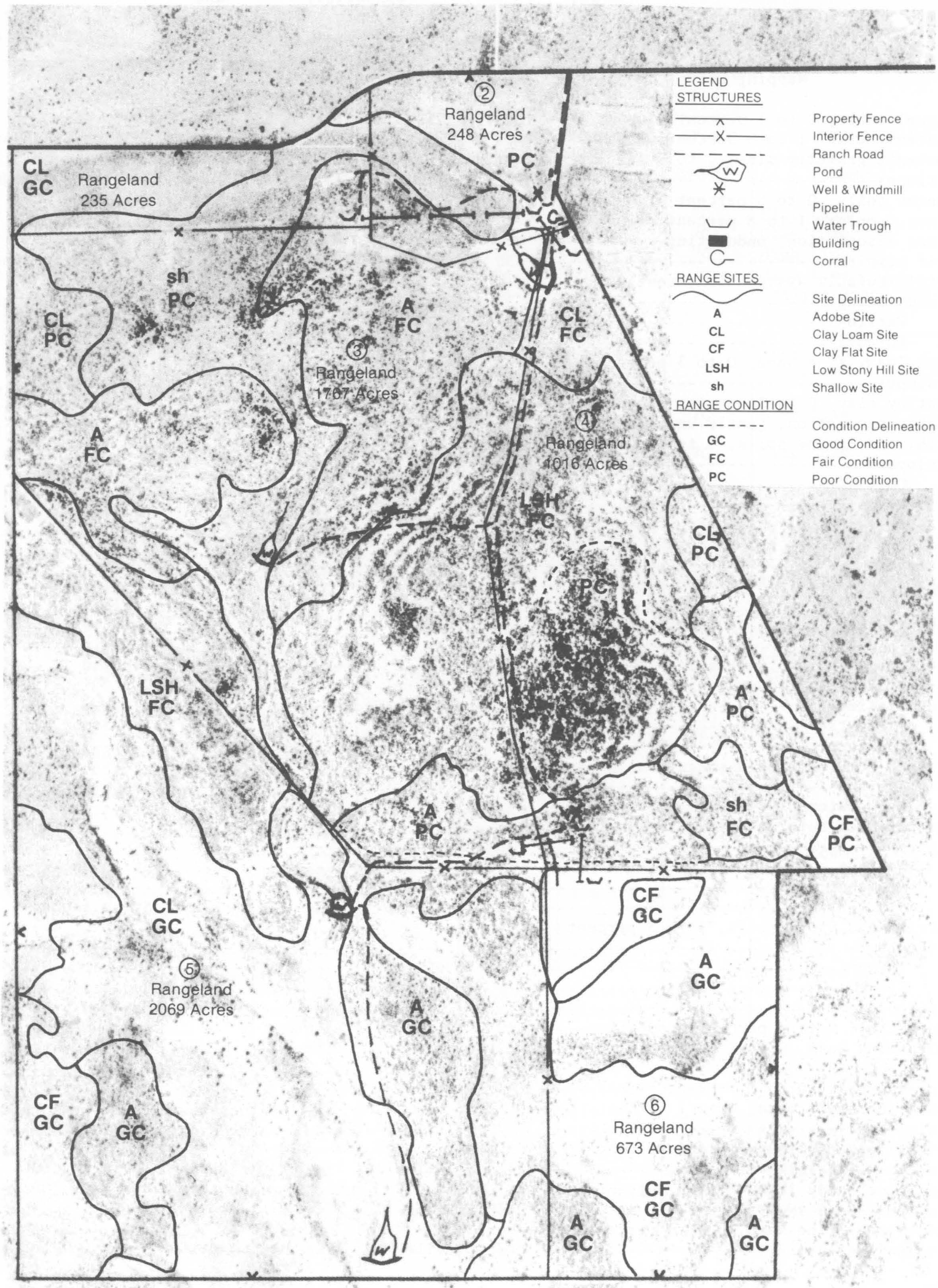

N
McB
PrB
RED
1796
KnB
MeB
VcA
KnA
McA
TAD
RkD
Little Comanche Creek
Rancheros Creek
Little
W

PLAN MAP

RANCH NAME: Your Ranch

MAP SCALE: 1:31,680

ACRES: 6008



Appendix G

Chemical Names of Herbicides Mentioned in Text

Common name	Chemical name
Clopyralid	3,6-dichloropicolinic acid
Dicamba	3,6-dichloro-*o*-anisic acid
Hexazinone	3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1*H*,3*H*)-dione
Picloram	4-amino-3,5,6-trichloropicolinic acid
Tebuthiuron	*N*-(5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-*N*,*N'*-dimethylurea
Triclopyr	((3,5,6-trichloro-2-pyridinyl)oxy)acetic acid
2,4-D	(2,4-dichlorophenoxy)acetic acid
2,4,5-T	(2,4,5-tricholorophenoxy)acetic acid

Appendix H

PRESENT VALUE OF $1 DUE AT THE END OF N YEARS, FOR USE IN PRESENT-VALUE ANALYSIS

Year (n)	4%	6%	8%	10%	12%	14%	16%	18%	20%
1	0.9615	0.9434	0.9259	0.9091	0.8929	0.8772	0.8621	0.8475	0.8333
2	0.9246	0.8900	0.8573	0.8261	0.7972	0.7695	0.7432	0.7182	0.6944
3	0.8890	0.8396	0.7938	0.7513	0.7118	0.6750	0.6407	0.6086	0.5787
4	0.8548	0.7921	0.7350	0.6830	0.6355	0.5921	0.5523	0.5158	0.4823
5	0.8219	0.7473	0.6806	0.6209	0.5674	0.5194	0.4761	0.4371	0.4019
6	0.7903	0.7050	0.6302	0.5645	0.5066	0.4556	0.4101	0.3704	0.3349
7	0.7599	0.6651	0.5875	0.5132	0.4523	0.3996	0.3538	0.3139	0.2791
8	0.7307	0.6274	0.5403	0.4665	0.4039	0.3506	0.3050	0.2660	0.2326
9	0.7026	0.5919	0.5002	0.4241	0.3606	0.3075	0.2630	0.2255	0.1938
10	0.6756	0.5584	0.4632	0.3855	0.3220	0.2697	0.2267	0.1911	0.1615
11	0.6496	0.5268	0.4289	0.3505	0.2875	0.2366	0.1954	0.1619	0.1346
12	0.6426	0.4970	0.3971	0.3186	0.2567	0.2076	0.1685	0.1372	0.1122
13	0.6006	0.4688	0.3677	0.2897	0.2292	0.1821	0.1452	0.1163	0.0935
14	0.5775	0.4423	0.3405	0.2633	0.2046	0.1597	0.1252	0.0985	0.0779
15	0.5553	0.4173	0.3152	0.2394	0.1827	0.1401	0.1079	0.0835	0.0649
16	0.5339	0.3936	0.2919	0.2176	0.1631	0.1229	0.0930	0.0708	0.0541
17	0.5134	0.3714	0.2703	0.1978	0.1456	0.1078	0.0802	0.0600	0.0451
18	0.4936	0.3503	0.2502	0.1799	0.1300	0.0946	0.0691	0.0508	0.0376
19	0.4746	0.3305	0.2317	0.1635	0.1161	0.0829	0.0596	0.0431	0.0313
20	0.4564	0.3118	0.2145	0.1486	0.1037	0.0728	0.0514	0.0365	0.0261
21	0.4388	0.2942	0.1987	0.1351	0.0926	0.0638	0.0443	0.0309	0.0217
22	0.4220	0.2775	0.1839	0.1228	0.0826	0.0560	0.0382	0.0262	0.0181
23	0.4057	0.2618	0.1703	0.1117	0.0738	0.0491	0.0320	0.0222	0.0151
24	0.3901	0.2470	0.1577	0.1015	0.0659	0.0431	0.0281	0.0188	0.0126
25	0.3751	0.2330	0.1460	0.0923	0.0588	0.0378	0.0245	0.0160	0.0105

SOURCE: Alpin, Richard D. and George L. Casler, Capital Investment Analysis, Grid, Inc., 1973. Tables were prepared by R.B. How, Department of Agricultural Economics, Cornell University.

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