TEXAS STATE BRUSH CONTROL PLAN

prepared by the

TEXAS STATE SOIL AND WATER CONSERVATION BOARD

1987

Foreword

Water has always been one of Texas' most valuable and least abundant resources. Many Texas towns and cities have experienced severe water shortages during the past few years. With the increased requirements for water placed on the state by continued growth, it is imperative that all methods of improving water supplies be examined.

There are now about 105 million acres of rangeland in Texas infested by brush. Over 32 million acres of this are classified as dense brush (31-100% canopy). It has been estimated that brush and weeds use 38% of the average annual precipitation that falls on the state. One report, which many people feel is conservative, states that by reducing brush density on the rangelands of the state 10 million acre feet of water could be saved annually.

While totally supportable figures for water savings through brush management are hard to establish, it is generally agreed that brush does waste significant amounts of water that would otherwise be available for a more beneficial use. A classic case of brush management increasing water yields occurred on Rocky Creek west of San Angelo. In the 1960's a majority of the landowners in the 74,000 acre watershed did extensive brush control work, more or less in concert. The creek, which had flowed constantly prior to the 1900's but had been dry since the 1930's, began flowing again as brush competition was reduced. The creek has continued to flow to date.

Probably no one would expect or even want to see all invading brush eliminated. The cost would be prohibitive and no known control method is permanent. Besides there are many negative impacts to such an extreme. The cost factor is much more severe today than it was even 10 years ago. While prices received for farm and ranch products have

declined, the cost of brush control has risen dramatically. As a result brush is spreading much faster than it is being controlled.

The passage of S.B. 1083 creating the Texas Brush Control Program is a clear signal that the people of Texas see a need to share a portion of the cost in bringing this problem under control. Urban people who have had to restrict water usage in the past, might not have had to do so without the brush infestations on the watersheds above their reservoirs.

State Brush Control Plan

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Section I. Introduction

1.1 Reasons for Development of the Plan

In a meeting on June 12, 1984, with Senator Bill Sims (San Angelo) and his staff, the State Soil and Water Conservation Board agreed to assimilate as much information as possible on the subject of increasing water yields from rangeland through brush management. Due to evidence presented by the USDA-Soil Conservation Service in "Grassland Restoration, Part V", discussions with various research groups and examples such as Rocky Creek, it was determined that a great many people support the idea that water yields may be increased for a more beneficial use by vegetative manipulation.

With the support of this evidence, Senator Sims introduced Senate Bill 1083 creating the Texas Brush Control Program which was signed into law in May of 1985. This program is to be administered under the jurisdiction of the Texas State Soil and Water Conservation Board. It basically consists of a mandate to prepare and adopt a state brush control plan including a comprehensive strategy for managing brush in critical areas and the designation of areas of critical need in the state where brush is contributing to a substantial water conservation problem.

The bill also includes the creation of a brush control fund in the state treasury which may be funded from legislative appropriations, money transferred to that fund from other funds, or other money required by law to be deposited in the brush control fund. These monies shall be used by the State Soil and Water Conservation Board to provide the state's share of the cost of brush control projects.

As mandated by law, this plan is written in the form of a

methodology to implement the program on a statewide basis. It contains the basic procedures necessary to carry out and administer such a program. There is no doubt, however, that individual project areas will require additional detail in the planning phase and some degree of latitude and flexibility in the implementation of the cost share program.

1.2 Intended Use of the Plan

This manual will be used as a guide in the development and implementation of the statewide brush control program and, more specifically, brush control projects. The Texas State Soil and Water Conservation Board and soil and water conservation districts will be the primary users of the manual since the State Board is responsible for administering the program. The plan is intended to provide the basic steps necessary to identify areas with a high potential for increasing available water through brush management. It also includes project application, prioritization, and planning procedures. Finally, the implementation of a cost-share program with the individual landowners in a project area is covered.

S.B. 1083 mandates that the State Board review the plan at least every two years. It is obvious that as the program progresses changes in procedures will occur. Results of research now in progress and on-the-ground experience will certainly need to be incorporated into the plan in the future.

1.3 The Soil and Water Conservation Program in Texas

The Texas Soil and Water Conservation Law was first passed in 1939. Through this legislation the State established its policy and created the Texas State Soil and Water Conservation Board. The

legislature defined state policy and the purposes of the State Board as follows: "It is hereby declared to be the policy of the Legislature to provide for the conservation of soil and soil resources of this state, and for the control and prevention of soil erosion; and thereby to preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist in maintaining navigability of rivers and harbors, preserve wildlife, protect the tax base, protect public lands, and protect and promote the health, safety, and general welfare of the people of this State."

The State Board is made up of landowners elected from five zones of Texas. It has the responsibility of coordinating the programs of 205 soil and water conservation districts. It operates as the liason between the districts and the State, its legislature, the governor and other state agencies. In its supportive role to districts the State Board obtains appropriations from the legislature for staff to carry out state-level soil and water conservation responsibilities. These include administration of certain federal assistance programs such as the Small Watershed Program and activities under the Resource Conservation Act and the Rural Clean Water Program.

State Board field representatives give direct assistance to directors of districts in carrying out their planning, administrative, and problem-identification activities.

Appropriations from the State for matching funds to districts are obtained and allocated by the State Board. More recently, appropriations have been received for use by districts in providing technical assistance to help landowners apply conservation practices.

The Association of Texas Soil and Water Conservation Districts is an organization made up of district directors. It is dedicated to

protecting the districts' common interests and those of owners of agricultural land to safeguard renewable natural resources. The Association devotes itself to educational, scientific, charitable and religious work relative to the conservation of soil, water and other renewable natural resources.

The governing structure of the Association is much like the State Board; however, the State Board is an agency of state government, whereas the State Association is a chartered non-profit organization, composed of and administered by district directors. The State Board and the Association work together under the guidelines of a Cooperative Agreement.

As stated earlier there are 205 soil and water conservation districts in Texas which cover the entire state. The primary purpose of soil and water conservation districts is to work with farmers and ranchers and provide leadership to get conservation practices implemented. During the early years of the program, districts restricted their activities to this primary purpose. It wasn't long, however, until their wealth of knowledge was discovered. Today, districts are involved in a myriad of activities.

The governing body of each district consists of five directors elected by landowners. Each district is divided into five zones with one director representing each zone. Legal qualifications provide that a director must live in a county all or part of which is in the district. In addition, he must be 18 years of age, and own land in the zone he represents and be actively engaged in farming or ranching.

A district may enter into working agreements with state and national governmental agencies; other legal subdivisions, and private organizations to carry out its functions. The nature of assistance by

any state or federal agency to a district is set forth in written agreements and memorandums of understanding.

Through the Soil Conservation Service, technical assistance is made available to farmers and ranchers in planning, design, layout and supervision of installation of conservation practices. In addition, information pertaining to soil surveys, land capability interpretations, conservation needs inventories, range and forestry inventories and engineering interpretations of soil is supplied. Conservation districts also join together with other districts, county commissioners courts, other local governmental entities and private groups to sponsor Watershed Projects and Resource Conservation and Development Projects.

The Texas State Soil and Water Conservation Board is the designated planning and management agency for agricultural and silvicultural nonpoint source pollution (P.L. 92-500, Section 208). Should nonpoint source pollution caused by agricultural or silvicultural practices be found in Texas, soil and water conservation districts will play a major role in selecting and implementing local pollution abatement plans.

Local districts are part of the formal review process for surface mining applications and reclamation projects. Their comments are sought for many other similar reviews.

In order to fulfill its responsibilities, each district develops a "Program and Plan of Work." The document is an inventory of the physical, economic, social and other conditions that affect soil and water conservation. The plan establishes needed goals and objectives. In addition, the plan specifies which agencies or private concerns are expected to assist in carrying out the objectives.

District "Programs and Plans of Work" are updated regularly to recognize and evaluate changes in agriculture, economy and population. For example, to be administratively efficient, districts regularly monitor changes in numbers of active farm and ranch plans. Conservation practices that were once feasible may become obsolete due to technological advances or changes in land use. Public attitudes and new resources and programs which become available are added reasons for updating programs and plans of work.

Districts operate on the principle that participation in conservation activities is voluntary. They recognize that land is the property of the owner and management is a responsibility of ownership. A farmer or rancher who desires to apply a conservation program to his land may receive assistance from his local district by making his desires known to the board. Representatives of the Soil Conservation Service, the Extension Service, the Agricultural Stabilization and Conservation Service and the Farmers Home Administration are also available to offer assistance to a landowner. Through cooperative efforts, these entities of government refer many landowners and operators to district boards.

Once a landowner's desires are known, the district, through the technical personnel of the Soil Conservation Service, will work with the landowner to develop a conservation plan tailored to his goals. If a published soil survey is not available for the district, Soil Conservation Service technicians must first establish soil characteristics of the property. A conservation plan includes a plan of operations that lists the intended practices, approximate cost to apply the plan and a schedule as to what practices will be applied each year. Conservation plans are based on soil types and land classes and

are designed to treat the land according to its needs and use it within its capabilities. After a mutually agreeable plan is developed, the individual is given the opportunity to sign a district agreement which includes the conservation plan. The plan is then brought before the board of directors for approval. After approval, the district is ready to assist with implementation.

In addition to their primary responsibility of helping individuals apply conservation practices on their land, districts are involved in numerous information and education programs directed toward informing all landowners, community leaders and others about the need for soil and water conservation. Agencies such as the Texas Agricultural Extension Service play an invaluable role in education programs such as these.

Districts work with the news media, banks, civic groups and other organizations to carry out timely, informational programs. Examples of activities include tours, Soil Stewardship Week observances, awards programs and other activities that illustrate what landowners are doing to conserve the soil and water on their land.

Section II. The Brush Problem in Texas

2.1A Historical Overview

Explorers and early white settlers found broad expanses of luxuriant grass that many considered to be "unlimited" grazing resources. Descriptions of Texas grasslands date back to the 1600's and 1700's when Spanish explorers repeatedly mention the abundant grazing that was available. The first settlers in the Austin colony on the lower Colorado and Brazos Rivers wrote home that grass grew belly-deep to a cow, and that livestock grew with amazing rapidity both in weight and numbers. Traders and hunters returned from the plains of West Texas with tales of vast grass plains on which thrived millions of buffalo.

Nearly all the early travelers and writers mention scattered trees, or mottes and bands of trees and other woody growth along the watercourses or rocky and gravelly hills. Mesquite and other woody plants were undoubtedly present in minor amounts, and producing seed which, given a chance, would surely spread over the grasslands.

It was to this land of "unlimited" grass that the white man brought his herds and flocks. The opening of Texas to settlement by Americans in 1820, its subsequent fight for freedom from Mexico, and annexation to the United States in 1845 started an immigration surge that didn't stop until the entire state was occupied. Always out on the frontier were the livestock men and their herds. By 1880, almost the entire range area of the state was being grazed and some was already being heavily used. There are records showing that as many as three hundred animals were grazed on a section in Central West Texas, and an animal to five acres or less on the Gulf Coast.

As the land was settled, several other factors affecting the situation occurred. The once common prairie fire was suppressed because settlers fought it and because the fuel load was removed by overgrazing. As proven in recent years with controlled burning of brush infested rangeland, fire is a powerful force in brush control. There was a change from the seasonal migratory grazing patterns of the buffalo and other wildlife to the yearlong, continuous grazing of domestic livestock. As fencing became prevalent, livestock was concentrated in even smaller areas where they and wildlife helped to spread the brush through their droppings and by other means.

Heavy use of the grass, intensified by drought, has caused an almost unbelieveable change in the natural vegetation. Most of the undesirable woody plants are adapted to dry climates and sparse cover. When the grass was removed by grazing and drought, the seed of the woody plants were able to germinate and get established. The result has been a "population explosion" of the undesirable species when they were given an opportunity to spread.

2.2 Past and Present Brush Management Programs

Soil and water conservation districts are a vehicle through which assistance is provided to landowners and operators. Section 1.3 discussed the many ways districts work with people. This section will discuss some programs available at this time through which producers receive assistance in applying conservation programs, including brush management.

The primary mission of the USDA Soil Conservation Service is to provide technical assistance on soil and water conservation and related matters to all landowners and operators. Its work is directed through

soil and water conservation districts, according to the terms of a memorandum of understanding with each district.

Resource conservation planning is the basis of SCS assistance. A conservation plan is the only sound method of properly applying conservation to a farm or ranch. Soil capabilities, land needs for protection and improvement, latest applicable scientific technology, and alternative treatments are the considerations involved in plan preparation.

Land treatment measures used in developing conservation plans are mechanical and vegetative. Measures applied to rangeland include range seeding, brush management, planned grazing systems and proper grazing use.

Soil surveys are a basic ingredient for technical assistance. Soil survey work in Texas is done in cooperation with the Texas Agricultural Experiment Station and other appropriate state or federal agencies. Soil surveys show depth, texture, structure, slope, acidity or alkalinity, shrink-swell potential, corrosivity and other important soil properties. Soil information is first recorded on aerial photographs. Selected samples are analyzed in characterization laboratories. When the field work is completed, the information is published in a soil survey.

There are 31 districts in East Texas with major forestlands. These districts can take advantage of the technical assistance available through the Texas Forest Service, which provides statewide leadership in forestry, technical assistance to the wood products industry, and management services to private landowners. Forest Service Programs include wildfire detection and suppression, pest control, and operation of its own tree seedling nursery.

The Agricultural Conservation Program (ACP) is administered by the Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture with emphasis on enduring practices, ACP provides federal cost-sharing to farmers and ranchers for carrying out approved soil, water, woodland and wildlife conservation practices on their land.

Funds for cost-share use in each program year are authorized by congress and then allocated to ASCS state committees. The ASCS state committees, in turn, allot funds to farmer-elected ASCS county committees to pay a portion of the local farmer's cost of carrying out certain measures.

The annual program at the state and county level is developed by ASCS committees with input from the Soil Conservation Service, Forest Service, Soil and Water Conservation Districts, and State Soil and Water Conservation Board. These programs are also developed with the counsel of the Agricultural Extension Service, the Farmers Home Administration, representatives of local agencies and non-governmental organizations.

The other major financial assistance program operating in Texas is the Great Plains Conservation Program administered by the Soil Conservation Service through local soil and water conservation districts. The program was authorized by the 84th Congress and broadened in scope in 1969 by the 91st Congress. In 1980, Texas was authorized to add 24 counties to the previous 123 counties eligible for assistance.

Through cropping and grazing systems, changes in land use, and application of lasting conservation measures, greater stability is brought to the Great Plains area. This program is based on a long-term

conservation plan developed by the landowner and technicians of the Soil Conservation Service. When the plan is agreed upon, it is approved by the board of the local soil and water conservation district and becomes a contract.

Upon signing a contract, the plan can be carried out as rapidly as the landowner is able to get the work done. No contract can be for more than ten years, and cost-share may not exceed 80% for any single practice. The determination to participate in the program is voluntary on the part of the landowner. The plan covers all land in a single operating unit of the landowner.

A state program committee chaired by the state conservationist of SCS is made up of: chairman of the state ASCS committee, state director of FmHA, state director of FCIC, a representative of the Forest Service, director of the Texas Agricultural Extension Service, director of the Texas Agricultural Experiment Station, and a representative of the State Soil and Water Conservation Board. Representatives of other interested agencies and groups are invited to participate. This committee gives overall leadership to the program.

Soil and water conservation districts are actively involved in sponsoring educational activities to acquaint landowners and others of the need for conserving soil and water resources. While districts work with many groups and agencies, including the Soil Conservation Service, the Agricultural Research Service, the Texas Forest Service and major colleges and universities, the one agency specifically charged with the responsibility of carrying out education programs is the Texas Agricultural Extension Service.

The basic function of the Extension Service as stated in the law is "...to aid in diffusing among the people of the United States useful

and practical information on subjects relating to agriculture and home economics, and to encourage the application of the same..." It is headed by a director selected by TAM University and approved by the Secretary of Agriculture.

The Extension Service is designed to take knowledge directly to the people. County extension agents, who live and work with people in a designated county, form the basic unit of the Extension Service, and serve as a link between research and its practical application. They conduct educational programs to help people use scientific information to solve common problems and utilize available resources.

In order for the soil and water conservation program to keep pace with changing agricultural situations,research must be conducted on an ongoing basis. New approaches to fit innovative conservation practices to modern farming and ranching techniques are necessary. There are several oganizations in Texas which conduct and coordinate research in agriculture. The USDA, Agricultural Research Service and the Texas Agricultural Experiment Station are available to institute needed research on problems identified by soil and water conservation districts. Texas Tech University has a major agricultural research program as well as other universities. The Forest Service conducts and coordinates for silviculture. Major research efforts include the selection of genetically superior trees and increasing wood utilization.

ARS is an agency of the U.S. Department of Agriculture and generally focuses its efforts on national or regional problems. TAES is an agency of the State and is primarily concerned with state and local problems. Together these agencies form a cooperative system to carry out the basic and applied research necessary to insure dependable

supplies of food and fiber and to maintain and protect the natural resource base. The Agricultural Research Service is organized into eleven geographic areas. The Southern Plains Area of ARS is composed of two locations in Arkansas, five field locations and two work sites in Oklahoma, and nine field locations and five work sites in Texas. The SPA headquarters is located in College Station, Texas.

The Experiment Station is established as the State Agricultural Research Agency in Texas. It is administered by the Board of Regents of Texas A&M University System. The Experiment Station cooperates with other state and federal agencies and with colleges and universities throughout the State in planning, coordinating and conducting agricultural research. Research activities are organized to provide studies pertaining to problems of the highest priority to modern agriculture.

Districts, through working agreements, often join together with other soil and water conservation districts, county commissioner's courts, other local governmental entities and private groups to sponsor special conservation projects.

The Watershed Protection and Flood Prevention Program is administered by the Soil Conservation Service and is carried out under three acts of congress. The Flood Control Act of 1944 approved operations on 11 major watersheds. The 1953 Appropriations Act for the Department of Agriculture authorized the SCS to install flood prevention programs in 74 small (pilot) watersheds. Public Law 566, the Watershed Protection and Flood Prevention Act, was enacted in 1954. P.L. 566 provides for local initiation and participation, with SCS help, in upstream watershed projects.

The State Board has received a total of 283 applications for

assistance under the P.L. 83-566 Program. Of these, 123 have been approved as feasible, and 102 have been granted planning priorities. There have been 85 workplans authorized for construction and 31 projects have been completed. Under all of the watershed progams, 1,783 floodwater retarding structures and 300 miles of improved channels have been constructed.

Local groups, such as conservation districts, cities and counties can often get help to solve critical flooding problems by sponsoring a watershed project. Local sponsors obtain right-of-ways, share certain costs and maintain completed projects. The SCS administers the program and helps the sponsors plan and install projects.

2.3 Brush Control Methods

Brush management is a practice that controls the distribution, numbers, and species of brush. Brush control can be accomplished by mechanical, chemical and biological methods, or by controlled burning. The practice will restore and improve vegetative cover by reducing competition for nutrients, water, and sunlight brought about by dense stands of brush. The amount and distribution of brush to be manipulated is dependent on the type and use of the land.

Common methods of mechanical brush control consist of tree dozing, rootplowing, roller chopping, chaining, grubbing, rhone plowing, mowing (shredding), girdling, and handgrubbing.

Tree dozing consists of uprooting individual trees with a dozer. Tree dozing is used when selective brush clearing is desired or when other forms of brush clearing do not produce the expected results.

When rootplowing, a large cutter blade is run underneath the soil to cut roots. Deflectors project upward and backward from the cutter blade to push the roots to the surface.

Chaining consists of pulling brush down by dragging a large naval anchor chain between two crawler tractors. Chaining may be followed by treedozing to ensure that all brush is properly uprooted and eliminated.

In areas too rocky to rootplow and where treedozing will not adequately control brush, grubbing can be used. A grubber is a blade similar to the blade of a rootplow designed to fit the front of a dozer. The blade is used to cut and dig the roots out as the dozer pushes the brush over.

To remove light stands of brush or control regrowth, rhone plowing, mowing or shredding is often used. A rhone plow is a large,

heavy off-set disc plow generally pulled behind a crawler tractor. It plows under small brush and breaks up buried root systems while providing an excellent seedbed for seeding operations.

Mowing or shredding provides temporary brush control by chopping down short growths of brush. Consequently, needed sunlight and increased soil moisture are provided for grass production.

Girdling consists of cutting a ring around a tree near its base. The practice very effectively kills most species. Girdling is not used extensively as a brush control measure, but in certain cases, it is the preferred method.

Hand grubbing is the practive of manually removing and grubbing out the bud zone of brush using axes and grubbing hoes. Hand grubbing is normally used on small stands of brush not easily managed by other methods of brush control.

If desirable, mechanical brush control can be followed by raking and stacking. The brush can then be burned or it can be left in stacks to provide wildlife protection or erosion control. Roller chopping, a companion brush control practice that can be used in lieu of raking and stacking for small brush, consists of pulling a large, heavy roller with cutting blades over downed brush. The blades cut the brush into small pieces and leave a cover on the land similar to a stubble mulch. Roller chopping is generally used as a follow up to rootplowing in South and West Texas. In areas where brush stem diameter is predominantly four inches or larger, roller chopping is normally ineffective.

Chemical brush control has become popular in the last 20 to 30 years. This practice may require repetition every five or six years to obtain desired control. Common chemicals used in the past to control

brush include 2,4,5-T, 2,4,5-TP, 2,4-D, dicamba, and picloram. The chemicals are normally mixed with agents such as diesel fuel, and sometimes surfactants, which help increase penetration and translocation of the chemicals within target plants. Water is normally used to dilute the mixture to achieve the desired application rate. Various mixtures of the chemicals are used depending on the type of application and plant species to be killed. Applications can be made by aerial spray, hand basal spray or by pouring chemicals around the tree base.

With the demise of 2,4,5-T, a large void was left in the chemical brush control business. Several large chemical companies have recently released chemicals to replace 2,4,5-T. There have also been some innovative new approaches to dispensing chemicals in pelletized forms.

Biological control is normally limited to the control of regrowth after some form of mechanical brush control has been applied. Goats suppress regrowth because they browse the buds before leaves can form, thus preventing stem elongation. One limitation on such a system is that all sprouts needing control must be within reach of goats. Large numbers of goats, two to four per acre, must be concentrated on the area for short periods of time followed by rest periods to allow recovery of the native grasses.

Brush management can be accomplished in some instances by controlled burning. In the eastern portion of Texas, burning is used to control running live oak, yaupon and to control dense patches of regrowth. Research is largely complete on controlled burning of mesquite and juniper in central and west Texas and is currently determining the effectiveness of burning on many other plant species in other portions of the State. To produce a successful burn, soil

moisture should be high and grasses should be dormant or semidormant. There should be adequate undergrowth to act as fuel to carry the fire. Prior to a burn, proper grazing management may be used to ensure sufficient vegetation to act as fuel. Where stands of brush are so dense that competition does not allow grasses to grow, chemical treatment and grazing management may be used to thin the brush and produce adequate vegetation for fuel supplies before burning is attempted. Precautionary measures, such as obtaining permits, building firebreaks, having the required manpower, tools, and equipment on hand to control a fire should be taken in order to ensure safety. In addition, adjoining landowners should be notified and all regulations concerning outdoor burning should be observed.

Brush management is applicable on all grasslands where dense growths of brush severely deplete desirable vegetative cover. Brush management coupled with appropriate grazing practices will improve or restore a good vegetative cover by eliminating competition for nutrients, soil moisture, and sunlight. Improved vegetative cover will improve water infiltration rates and reduce soil loss by decreasing the amount and velocity of runoff and will provide more grazing for livestock. Chemical and mechanical brush management practices require large initial expenditures. All brush management techniques require some curtailment of grazing use. These large expenditures and the limited use of lands for grazing purposes can create financial hardships on most ranchers.

Range seeding is the practice of re-establishing vegetative cover on rangeland by seeding methods. Range seeding increases the stand of desirable vegetation which improves productivity and aids in reducing erosion and runoff. Range seeding operations should accompany most

brush clearing activities.

The type of seed or seed mixture to be used is dependent on the desired results and on the specific conditions relating to the seeding. To re-establish natural, native grass cover climax nativegrass species should be used. If it is desirable to establish quick growing introduced species of grass to provide forage and cover in anticipation of resident native grass recovery over a period of time, a pure mixture of the introduced species or a mixture of the introduced and native species can be used. If it is known that an adapted introduced species of grass will persist, perform at least as well as a native, and provide adequate cover, pure plantings of these species may be used.

The seedbed prepared for range seeding should be tilled or disturbed soil comparatively free of competing plants. If the seed is to be broadcast, seeding should be done before rainfall causes crusting of the soil surface. When heavy clay soils have been rootplowed, additional tillage such as raking, disking, or chopping may be necessary. Soil that has been disturbed by individual treedozing will normally be satisfactory as a seedbed. Range seeding on former cropland requires a well prepared very firm seedbed that is as good as that prepared for normal cultivated crops. Seedbed preparation is very important in getting a satisfactory stand in most cases.

Seeding is applicable on all rangeland, native pasture, and grazeable woodland which does not have a sufficient amount of desirable forage plants. It is specifically applicable on lands being converted to rangeland, on old fields which have not been in cultivation for several years, on poor condition range with less than 20 percent of the climax grasses present. The practice is also applicable on areas that have been rootplowed or treated with other mechanical brush control

Table 1. Acres of Texas rangeland treated for brush and weed control--1940 through 1983.

Year[1]	Acres Treated						
	Brush			Weed			Prescribed Burning
	Total	Mechanical	Chemical	Total	Mechanical	Chemical	
1940	2,552,982*						
1941	1,902,261*						
1942	1,105,796*						
1943	657,091*						
1944	2,930,884*						
1945	1,116,796*						
1946	1,371,314*						
1947	1,212,959*						
1948	514,503*						
1949	740,743*						
1950	1,042,072**						
1951	1,289,610**		500,000				
1952	1,186,090**		500,000				
1953	1,034,155**		82,177***				
1954	1,013,668**		106,486***				
1955	1,279,068**		101,904***				
1956	1,095,550**	946,795	148,755				
1957	905,439**	688,212	217,227				
1958	1,170,466**	760,272	410,194				
1959	1,294,614**	828,055	466,559	1,997,628	1,489,654	507,974	
1960	1,496,249**	990,828	505,421	2,967,607	2,315,003	652,604	
1961	1,470,735**	816,990	653,745	2,522,743	1,944,722	578,021	
1962	1,319,667**	746,289	573,378	2,575,172	2,065,925	509,247	
1963	1,532,510**	836,594	695,916	2,881,427	2,210,230	671,197	
1964	1,315,011**	725,366	589,645	2,062,935	1,462,570	600,365	
1965	1,591,779**	776,485	815,294	2,921,432	1,739,261	1,182,171	
1966	2,048,048**	917,227	1,130,821	3,499,333	1,524,615	1,974,718	
1967	1,905,569**	939,179	966,390	4,358,475	2,280,635	2,077,840	
1968	1,631,113**	740,980	890,133	4,786,321	2,401,579	2,384,742	
1969	1,734,327**	751,973	982,354	4,301,324	1,970,072	2,331,252	
1970	1,920,244**	954,980	965,264	4,309,346	1,877,129	2,432,217	
1971	1,201,335**	750,728	450,607	3,652,287	1,492,772	2,159,515	
1972	1,774,074**	794,759	979,315	3,468,208	1,411,672	2,056,536	
1973	1,552,818**	627,979	924,839	3,741,210	1,684,566	2,056,644	
1974	1,945,101**	1,077,878	868,223	4,627,492	2,545,294	2,082,298	
1975	1,200,047**	614,189	585,858	3,257,466	1,757,861	1,499,705	
1976	1,248,804**	675,298	573,506	3,313,406	1,858,181	1,455,225	
1977	1,165,012**	572,077	592,935	2,945,101	1,141,141	1,803,960	
1978[2]	1,438,387						
1979[2]	1,578,000						
1980	1,974,410	845,501	1,128,909	4,792,122	2,491,054	2,301,068	200,266
1981	1,721,660	778,741	942,919	4,959,057	2,465,323	2,493,734	225,296
1983[3]	1,981,163	896,341	1,084,822	3,935,875	1,827,180	2,108,695	210,026
1984	1,526,175	796,852	729,323	4,005,607	2,017,827	1,987,780	267,932

* Acreages based on ACP summaries of cost-share

** Acreages based on county agent annual report summaries

*** Acreages based on county agent annual report demonstration summaries

1 1940 through 1977 data were compiled by Garlyn O. Hoffman, former Extension Range Brush and Weed Control Specialist.

2 Acreage provided by Soil Conservation Service

3 Data not collected for 1982.

that has caused significant soil disturbance.

Seeding will establish a vegetative cover on rangeland in a minimum amount of time. This will reduce the erosion potential from otherwise unprotected rangelands; however, it requires a major initial expenditure for brush clearing, seedbed preparation and seeding. Areas seeded must be deferred from grazing until the grass is well established. This could take up to two growing seasons with light grazing allowed only during the dormant season. Besides temporary loss of grazing, the producer could be faced with expenditures for fencing and occasional maintenance operations.

Deferred grazing is the practice of delaying grazing or resting grazing land during crucial periods of time. Deferred grazing is used to increase plant vigor and allow desirable plants time to reseed. Enhanced plant growth resulting from deferment will increase water intake into the soil and protect it against erosion. In addition, deferred grazing is beneficial to production of livestock.

After such practices as range seeding and brush manipulation, deferred grazing is necessary to insure that forage plants obtain a good stand. Normally after range seeding, the area will be deferred for one or two complete growing seasons. When introduced species are seeded, they need to be deferred from grazing until they become established.

After brush control, and reseeding if necessary, deferment periods vary according to prior brush density, range condition, plant vigor prior to brush control, type of treatment, and the type of growing season following treatment. Deferred grazing is also used to control weeds, to develop feed reserves, and to allow recovery from damage caused by fire, drought, or insects.

Proper grazing use is the management of grazing intensity. Proper grazing intensity will limit the amount of forage removed from the existing vegetation. Proper grazing use in accordance with recommended grazing heights is a necessary consideration of planned grazing systems. Most pastures or ranges will have certain areas preferred by animals for grazing because of topography, water supply, soil type, forage quality, or other factors. These key areas are where overgrazing will lead to plant depletion if not properly managed. The general philosophy of adjusting grazing animals to the extent that half of the leaf surface is eaten and the other half left for the benefit of the plant and soil resources is scientifically sound. The application of this principle is not as simple as it might appear since variations in rainfall and other climatic conditions can radically change forage production. Usually it is not economically feasible to adjust livestock numbers to these temporary changes in forage production. However, most forage species can tolerate short periods of grazing abuse with no permanent damage to the vegetative cover. Only in periods of extended drought are major adjustments in livestock numbers necessary.

Proper grazing use is applicable on all grazing land. It is an effective method of maintaining or improving vegetative cover. After an initial establishment period, increased forage will most likely enable a producer to stock at a rate that will maximize income while protecting his resources.

. . . . . METHODS OF BRUSH CONTROL BY SPECIES . . . . . .

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
ACACIA, Blackbrush	(See Chaparral)	
ACACIA, Catclaw and Twisted (Huisachillo) Mimosa, Catclaw Components of Chaparral of S. Texas but also on gravelly and sandy soils, W. and SW Texas	Chaining, chopping	Temporary setback, not generally recommended
	Rootplowing	Dense stands with little grass, for 15-inch and higher rainfall belt.
	Dozing	Adapted where scattered plants, small areas
	Basal treatment, chemicals	Adapted where scattered plants, small areas
AGRITO Gravelly and rocky soils, SW and West Texas	Dozing or hand grubbing	Scattered plants, small areas
	Rootplowing	When in dense stands, mixtures with other brush on deeper soils.
	Basal treatment, chemicals	Adapted scattered plants, small areas.
ASH (See Hardwoods)		
BACCHARIS A common invader into old fields, pastures of Central and East Texas	Mowing, shredding chopping	Repeated treatment required, 2 to 3 times a year, for 3 to 5 years for effective control.
	Disking	Where seeding is needed.
	Dozing	For large plants, scattered or in small areas.
	Rootplowing	For dense stands and where seeding is needed.
	Basal treatment, chemicals	Scattered to moderate stands, small areas.
	Ground foliage sprays	For controlling small areas, seedlings.
	Aerial sprays	Large areas, 50 acres or more, no danger to crops.
CACTUS - Pricklypear and Tasajillo	Grubbing, dozing, raking	Adapted to small areas, scattered stands, plants should be stacked to decay.
	Railing	Thick infestations, mostly cactus, no large trees present.
	Disking, chaining, chopping	Temporary control, not generally recommended, need repeated follow-up for control.
	Ground foliage spray	For scattered plants, small areas.

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
Cholla	Grubbing, dozing	Small areas and scattered plants
	Chaining	Large areas, thick stands.
	Ground foliage spray	Scattered plants, small areas
CEDARS (See Junipers)		
CHAPARRAL Mixture of many species of South and Southwest Texas	Chaining, chopping, shredding	Temporary setback; adapted where grasses present, no seeding needed. Effective when followed up with goats, or other treatment, or as initial treatment to knock down brush to facilitate root-plowing
	Disking	Not generally recommended, too many root-sprouting species.
	Dozing	Adapted to small areas.
	Rootplowing	Most effective treatment, usually needs to be followed with seeding. Tends to spread pricklypear; whitebrush often returns quickly
	Chemical methods	No effective control: not recommended.
CONDALIAS Lotebush, Bluewood (Brasil) Knifeleaf Components of Chaparral of S. and SW Texas, but also understory with mesquite in West Texas	Chaining, chopping, shredding	Not recommended
	Dozing or grubbing	Scattered plants, small areas of dense growth
	Rootplowing	In dense stands, and where seeding is needed
	Basal treatment,	Scattered plants, single stemmed, small areas
COYOTILLO Poisonous shrub of SW and South Texas	Grubbing, dozing	Scattered plants
	Rootplowing	When associated with thick Chaparral of South and Southwest Texas
	Basal treatment	Scattered plants
	Pelletized fenuron	Scattered plants
CREOSOTEBUSH AND TARBUSH Desert shrubs common to Trans-Pecos and Southwest Texas	Disking	Where seeding is possible and practical on good sites. Not recommended where mesquite present or seeding not practical.
	Railing, chopping	Temporary control only used where grass is sufficient to make good recovery.
	Rootplowing	Only where extra water, deep soils, possible to reseed to high producing grasses.
	Chemical methods	None effective

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
ELM (See Hardwoods)		
GUAJILLO Common on shallow and rocky soils of SW and South Texas. Desirable to control excessive amounts.	Chaining, chopping, shredding Rootplowing Chemicals	Temporary setback, effective to knock down brush so that goats, livestock can reach browse. Only where component of dense Chaparral and seeding needed. None effective
HACKBERRY (See miscellaneous trees)		
HARDWOODS Ash, elm, blackgum, sweetgum, hickory, red oak, white oak	Dozing Girdling, frilling with basal treatment Tree injector Aerial spraying	For land clearing, scattered trees, and small groves Large scattered trees, small groves. Most effective with basal treatment Large trees, scattered trees or small groves Small areas or groves, and scattered trees Large areas of dense stands, 2 years successive treatment needed.
HUISACHE Invader in grasslands of South Texas and Gulf Coast	Dozing, grubbing Rootplowing Basal treatment Aerial spraying	Scattered trees, small areas Thick stands with little or no grass, needing seeding Scattered stands, small areas Not effective
JUNIPERS - (Cedars) Redberry Oneseeded Common to rocky soils of Western Texas	Dozing Chaining Rootplowing Chemical methods	Most effective control Not recommended, too many young plants missed Only on deep soils and where seeding is needed None effective
Ashe or blueberry Common on limestone soils of Central Texas	Cutting, axing Chaining	Effective control if all green leaves and stems are removed. Effective for old stands of trees but not for young plants.
Eastern redcedar Common on sandy soils of central and east Texas	Dozing Chemical methods	For scattered plants and small areas. None effective

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
LECHUGUILLA An agave of rocky soils of Southwest and West Texas	Grubbing	Most effective control but expensive
	Ground foliage spray	Scattered plants on more productive sites
MESCALBEAN (Locally called Mountainlaurel) Evergreen shrub of Southwest and South Texas, usually on rocky hills.	Chaining	Useful only to knock down plants so that goats can reach leaves
	Rootplowing	Effective only on deeper soils where seeding needed
	Basal treatment	Scattered plants and small areas.
MESQUITE Common to most of Texas	Dozing, grubbing	Effective control only if plants dozed or pulled out below bud zone, scattered trees and small areas
	Chaining	Adapted only to tree-type, single-stemmed plants on loose or moist soils so plants are pulled out with roots. Also useful to knock down large trees to facilitate follow-up treatment, such as rootplowing or spraying.
	Rootplowing	Most useful control method where soils are deep and seeding is needed. Also good method where mixtures with other brush.
	Basal treatment	Adapted to scattered trees, small areas. Large trees should be frilled for better results.
	Aerial spraying	Large areas, but where there is little underbrush, and seeding not needed.
MISCELLANEOUS TREES Hackberry, Mulberry, Pricklyash, Sumac, Soapberry (Wild chinaberry), Willow.	Same treatments as the Hardwoods except aerial spraying is not effective	
OAKS Live Common to Central Texas and South Texas	Chaining	Adapted to dense stands for knocking down trees so that goats can reach leaves
	Dozing	Small, dense groves
	Rootplowing	Adapted to live oak thickets of coastal area where seeding needed.
	Basal treatment	Scattered trees - apply in frill or notch

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
Blackjack and Post Common on "Post Oak Strip" and other parts of East Texas and Cross Timbers areas.	Chopping, shredding	For control sprouts or for knocking down small brushy type plants
	Chaining	For knocking down trees so that goats can reach leaves and sprouts.
	Dozing	Scattered trees and small areas
	Basal treatment	Scattered trees or small groves, larger trees should be frilled or girdled.
	Tree injector	Scattered trees or small groves
	Aerial spray	Dense woods, large areas. Two years successive treatments needed, and follow-up to control underbrush by goating, burning, chemical foliage sprays.
Shin Oaks Common on sands of West and NW Texas and to rocky soils of Edwards Plateau, Hill Country and Grand Prairie	Chopping, shredding, chaining	Used as temporary control to knock down brush so goats can reach it, or to set back brush, later to be sprayed.
	Dozing	Adapted only to small areas.
	Aerial sprays	Adapted for control sand shin oak in 2 or 3 applications. Trials being developed for control shin oaks of limestone areas.
	(or ground foliage sprays for small areas)	
Red, White, Texas (See Hardwoods)		
PERSIMMON, COMMON AND SASSAFRAS Common invaders into old fields and grasslands of East Texas	Mowing, shredding	Useful for control sprouts and young plants
	Dozing, grubbing	For scattered trees, small groves
	Basal treatment	Scattered trees and small groves. Apply in frill or to cut stumps for larger trees.
PERSIMMON, TEXAS South and Southwest Texas, often in rocky soils	Dozing	Scattered plants
	Rootplowing	Only when in dense stands of Chapparral
	Chaining	Temporary control to knock down plants so goats can reach leaves.
RETAMA Invader in South Texas and Gulf Coast	Dozing	Scattered plants
	Rootplowing	In dense stands where seeding is needed
	Basal treatment	Most practical treatment

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
ROSE, MACARTNEY AND WILD Invaders in Gulf Coast and Southeast Texas	Mowing, shredding, chopping	Temporary treatment, requiring repeat for control, adapted to pasturelands, small areas.
	Ground foliage spray	For scattered plants, several treatments required. Also, as follow-up on plants that have been killed back by fire, mowing, or other means.
	Aerial spray	For dense stands, large areas. Several treatments needed to get control.
SAGEBRUSH, SAND Common to sands of Northwest and West Texas	Mowing, shredding, chopping	Adapted to small areas, repeated treatment required for 2 successive years, then every 3 to 5 years.
	Ground foliage spray,	Small areas.
	Aerial spray	Large areas of dense infestation.
SALTCEDAR Common invader on all watercourses, wet areas in West Texas	Dozing, grubbing	For small areas of scattered trees.
	Rootplowing	On large, dense areas where seeding needed, and soils not too wet or too sandy.
	Mowing, shredding	Adapted for control small plants, sprouts, and seedlings. Repeated treatment needed.
	Ground foliage spray	Small areas, several treatments needed
	Aerial spray	Large areas, several treatments needed.
SASSAFRAS (See Persimmon, Common and Sassafras)		
SUMAC (See Miscellaneous Trees)		
SWEETGUM (See Hardwoods)		
TARBUSH (See Creosotebush and Tarbush		

SPECIES	RECOMMENDED CONTROL METHODS	ADAPTATIONS
WHITEBRUSH (Beebrush) Common on valley, deep soils of South and Southcentral Texas	Chaining, mowing, shredding, chopping	Adapted only for knocking down plants so that goats can reach leaves, or temporary control requiring repeated treatment.
	Rootplowing	Not effective control, plants tend to take root, continue growth.
	Grubbing, dozing	Effective on small areas.
	Disking	Effective where no other brush.
	Foliage spray	Expensive, 30% kill expected. Requires repeated follow-up for control.
YAUPON Common as underbrush in post oak and other woodlands.	Dozing, grubbing	Scattered plants, small areas
	Basal treatment	Scattered plants
	Aerial spray	Large areas, low kill so follow-up needed, retreatment, burning, basal treatment.
	Controlled burning	Where mixtures of hard-to-kill species, possible to prevent wildfires.
YUCCA Sandy and gravelly soils of Panhandle, West Texas	Ground foliage spray	Small areas, dense stands
	Aerial spray	Large areas of dense stands

. . . . . SEEDING RATES FOR GRASSES IN TEXAS . . . . . .

The table below lists the most common grasses planted in Texas and their recommended seeding rates for row, drilled, or broadcast seedings as adapted.

GRASS	POUNDS PLS AC.		POUNDS COMMERCIAL AC.	
	NORMAL ROWS	BROADCAST OR DRILLED	NORMAL ROWS	BROADCAST OR DRILLED
Bahiagrass	-	-	-	12.-16.
Bermudagrass (Sprigs)	-	-	8-10 bu.	16-24 bu.
Bermudagrass (Seed)	-	-	1.-2.	2.-4.
Bluestem, Angleton or Medio	.3-.5	.6-1.	-	-
Bluestem, Big and Sand	1.5-2.	.3-4.	-	-
Bluestem, Cane	.4-.6	1.25-2.	-	-
Bluestem, Caucasian	.3-.5	1.-1.5	-	-
Bluestem, Gordo	.4-.6	1.-1.5	-	-
Bluestem, Kleberg or KR	.3-.5	1.-1.5	-	-
Bluestem, Little or Native Mix.	1.-1.5	2.-4.	-	-
Bluestem, Pretoria 90	.4-.6	.7-1.	-	-
Bristlegrass, Plains	1.2-2.*	2.7-4.*	-	-
Brome, Smooth	-	-	-	10.-14.
Buffelgrass	1.-1.5	2.-3.	2.-3.	3.-5.
Buffalograss (Bur)	1.6-2.*	4.-6.*	-	-
Buffalograss (Grain)	-	-	.5-1.	1.-2.
Cottontop, Arizona	.3-.4	1.-2.	-	-
Dallisgrass	-	2.5-4.	-	-
Dropseed, Mesa or Sand	-	.9-1.2*	-	-
Fescue, Tall or Meadow	-	-	-	10.-14.
Grama, Blue	.4-.7	1.5-2.	-	-
Grama, Black	.5-.8	1.-2.	-	-
Grama, Sideoats	2.-3.	4.-6.	-	-
Indiangrass	1.5-2.	3.-4.	-	-
Johnsongrass	-	-	5.-7.	12.-20.
Kleingrass	.5-.7	1.5-2.	-	-
Lovegrass: Lehmann, Sand, Weeping or Wilman	.5-.7	1.-2.5	.6-1.	1.2-3.
Orchardgrass	-	-	-	10.-14.
Panicum, Blue	.8-1.	1.6-2.	1.-1.5	2.-3.
Pappusgrass, Pink and Whiplash	.75-1.	2.25-3.	-	-
Rhodesgrass	.3-.5	.7-1.	1.-1.5	2.-3.
Ryegrass, Perennial	-	-	-	10.-14.
Sacaton, Alkali	.25-.4	.75-1.	-	-
Sorghum almum	-	-	5.-7.	10.-15.
Sprangletop, Green	.5-.7	1.5-2.	-	-
Switchgrass	1.-1.5	3.-4.	1.5-2.	4.5-6.
Trichloris, 2 and 4 flower	.3-.5	1.-1.5	-	-
Vine-mesquite	1.5-2.*	3.6-5.*	-	-
Wheatgrass, Western	-	-	3.-4.	8.-10.
Wintergrass, Argentine	.3-.5	1.-1.5	-	-
Wintergrass, Texas	2.-3.*	6.-8.*	-	-
Wildrye, Canada	-	-	6.-8.	12.-16.

*These rates are based on "Pure Seed" rather than PLS.

Seeding rates are based on a guide of about 20 seed units per foot of row. or per square foot. Rates for some species are adjusted to what experience has shown is required to get satisfactory stands.

2.4 Magnitude of the Present Brush Problem

Brush invasion has long been recognized as a severe conservation problem in Texas. In inventories of conservation problems published by the Association of Texas Soil and Water Conservation Districts in 1963, 1970, and 1976 undesirable brush and weeds ranked as the number one problem on rangeland. In a long range plan prepared by the Texas State Soil and Water Conservation Board in 1980, undesirable brush and weeds was reported by 148 districts as one of their five most critical problems. Since 1948, the USDA-Soil Conservation Service in Texas has conducted four statewide brush surveys. Each survey has shown a steady increase in brush-infested land.

The brush survey published in 1973 showed 92 million acres occupied by brush. This was up 3.5 million acres from the 88.5 million acres reported in 1963. The most amazing thing about this is that the increase occurred in spite of the fact that dense brush was treated on nearly 30 million acres during the decade. Statewide results from the latest SCS survey completed as a part of the 1982 National Resources Inventory shows a dramatic increase in total brush to about 105.6 million acres. This figure includes 48.4 million acres with canopy coverage of greater than 20 percent. According to conservative treatment needs on rangeland figures gathered in the same 1982 inventory, 31,320,600 acres could not be adequately protected without brush management. Brush management and grass reestablishment would be necessary on about 10,182,800 acres of rangeland.

Mesquite is the most common and widely spread brush species in Texas. About 52 percent of the grasslands of the state are infested with mesquite, of which almost 16 million acres, 15 percent of the state total, are so densely covered as to suppress grass production

seriously. Mesquite now occurs over the entire state and has spread as far north as Kansas.

Mesquite is a prolific seed producer, and livestock and wild animals relish the ripe beans. A peculiarity of mesquite is that the seeds germinate more readily when they have passed through the digestive system of livestock, and thus are spread over wide areas. They readily become established when falling on bare or denuded ranges. Mesquite is difficult to kill because of the dormant bud zone on the base of the main trunk. When the top of the tree is damaged or removed, these buds sprout causing a dense second growth that is more of a problem than the original tree.

The junipers have spread with amazing speed since Texas was first settled. There are three species that have become problems: redberry, which is most common in West Texas; blueberry (also called "post cedar" because of its use for this purpose), found mostly on the limestone soils of the Edwards Plateau and Grand Prairie; and eastern redcedar, common in the post oak strip of the eastern part of the state. The fleshy fruit of the junipers is relished by many birds and some wild animals such as oppossums, rabbits, and foxes. Seeds pass through the digestive system of the birds and animals without being digested, thus spreading the plants.

Junipers produce such dense shade that grass is almost eliminated in "Cedar brakes". Dense cedar is a poor wildlife habitat as well as poor livestock country.

Cacti occupy more than 35 million acres in Texas and grow everywhere except in the "Piney Woods" of East Texas. Texas pricklypear, common in the southern half of the state, grows in large clumps sometimes 40 feet or more across, and six to eight feet high,

forming dense, impenetrable thickets. It is occasionally used as an emergency feed after burning the spines.

Engelmann and plains pricklypear are smaller species found mostly in western and northwestern Texas. Tasajillo, also called "jumping cactus" because the small branches fly off when the plant is touched, and "turkey pear" because turkeys are fond of the red, berry-like fruit, is often found in dense stands in Central and South Texas. Cholla is a larger, round-stemmed cactus that is common in West Texas, sometimes forming "forests" in valleys of the Trans-Pecos area.

Cacti spread rapidly on grasslands in low condition or with sparse cover because the pads or branches, and seed that have passed through birds and animals, can readily become established on bare ground. Although eradication has been attempted on millions of acres, reinfestation too often occurs within a few years. Cactus is troublesome on land where other brush has been controlled by mechanical means.

The oaks - live, post, and blackjack - are natural components of a savannah vegetation that characterizes a large part of Central and East Texas. Live oak covers more than 16 million acres, and a mixture of post and blackjack oak more than 11 million. Reduction of the grass cover, fire, and drought have permitted the oaks and an understory of associated woody species to thicken in stand. Over 7.5 million acres are now densely covered. Even though the leaves of the oaks have some browse value, and the acorns are excellent wildlife food, a dense stand of trees produces little useful forage.

More than 8.5 million acres are covered with shin oak, or "shinnery", with 2.5 million in dense stands. The shin oaks occur primarily in the Cross Timbers, on the sandy soils of the Rolling and

High Plains, and rocky soils of the Edwards Plateau. Although the leaves are good browse, a dense stand of shin oak produces little usable forage. The shin oaks are deciduous, leaving poor browse in winter. The buds in spring may also cause "shin oak poisoning".

Sand sagebrush is characteristic of deep sands of Northwest and West Texas, often associated with shin oak. It has some browse value, but like shin oak, is poor grazing when in dense stands. More than five million acres grow sagebrush, with 700,000 acres in dense stands.

Huisache and retama were introduced as ornamentals and shade trees into Texas in pioneer times. They have escaped into grasslands and are spreading rapidly in South Texas, now covering more than 2.5 million acres. Macartney rose is another introduced plant, brought in for a hedge planting about 1870. It has escaped and is rapidly spreading and has been found rather difficult to control. It is now found on 275,000 acres.

Whitebrush is a native of southern Texas where it once occupied lowlands as an inconspicuous shrub. It is commonly called "beebrush", because the white, fragrant flowers that it puts out soon after a rain attract great numbers of bees. Unfortunately, the plant spreads rapidly from both seed and root sprouts when the natural grass cover is reduced. It forms dense colonies that shade out the grass. Whitebrush has become a problem in the area immediately south of the Balcones Escarpment, in the valleys of the Edwards Plateau, and in the Central Basin, where more than six million acres are infested.

Guajillo is abundant in the hills of the Southwestern Edwards Plateau, and in the Rio Grande Plain. It is a good browse plant, but when the grass is depleted, the shrub thickens until the vegetation may consist of almost pure stands. Sheep on a diet of guajillo alone

sometimes suffer from "guajillo poisoning". Almost 1.5 million acres of the six million acres where this plant occurs are covered by dense stands where control is needed.

Saltcedar is an Old World plant brought to this country for use as windbreak, shade, and ornamental. It has now escaped to become an important pest along streams and reservoirs and in the irrigated areas of West Texas. It is a costly invader in that it transpires and wastes immense amounts of water each year. Saltcedar occupies more than a half million acres, and is rapidly spreading.

Yaupon and winged elm, each found on about 2.5 million acres of East Texas grasslands, have become serious problems. Common persimmon and sassafras are spreading on formerly cultivated fields and pasturelands and require repeated treatment for control.

Other woody plants that are locally acute problems are numerous. Creosotebush, tarbush, and lecheguilla are widespread in the Tran-Pecos. Yucca and catclaw acacia are abundant on sandy soils of the High and Rolling Plains. Lotebush is scattered and becoming a problem over wide areas of western and southern Texas. Flameleaf sumac becomes a pest on heavily used, burned over, or brush-treated grasslands in the central part of the state. Coyotillo, a poisonous shrub of Southwest Texas, and many other species such as pranjeno, guayacan, condalia, amargosa, and others constitute the chaparral of South Texas. Texas persimmon, mescalbean (locally called mountain laurel), and other shrubs are local problems in the Edwards Plateau, and the half-shrub, snakeweed, or turpentineweed, is common over large parts of West Texas.

Section III. Increasing Water Yields From Rangeland Management

3.1 Water Problem in Texas

Rapid population growth and economic development, coupled with a climate in which water resources are scarce, have imposed real and potential water supply problems in many areas within the State. In much of the State today, available storage capacity in existing surface-water reservoirs will barely be sufficient to meet water demand during critical droughts. Additional water supplies will have to be developed to meet growing needs.

Industrialization and population increases have resulted in steadily increasing water requirements and water quality protection needs for the State. Although the trend has been toward urbanization, a significant portion of the State's population still resides in rural areas, and recent trends indicate that the population of some areas is beginning to increase after decades of decline. Rural water systems generally have difficulty in providing dependable, uninterrupted service because they are relatively small in size and the low population density of service areas commonly results in relatively high costs per customer. Drinking water standards promulgated as a result of the Federal Safe Drinking Water Act have been adopted, in part, by the Texas Department of Health. These standards apply to all public water supplies; however, a number of rural and small community systems cannot fully comply with these standards without installing new, expensive, water treatment systems.

Extensive development of ground water has resulted in several problems; some being local in nature, while others are more widespread. In the Texas High Plains the rate of use of water stored in the High

Plains (Ogallala) Aquifer far exceeds the rate of natural recharge. In the Houston-Galveston area, large-scale pumpage of ground water has resulted in land surface subsidence and saline water encroachment in localized areas. Problems of water quality, both from natural and man-made causes, are expected to affect the suitability for use of water from portions of most of Texas' subsurface, water-bearing formations in the future.

Water quality problems, both natural and man-made, affect a significant part of the State's surface-water resources. Problems of naturally occurring salinity are particularly severe in the upper reaches of the Red, Colorado, Brazos, and Pecos River Basins and continue to plague development and full beneficial use of water resources in these basins. In these areas natural pollution, primarily sodium chloride, results from salt springs and salt flats within the drainage areas of the basins. In some areas this problem has been aggravated to some extent by oil and gas exploration and production activities.

Many of the man-made water quality problems occurring in Texas streams originate from highly populated urban areas, which include Dallas-Fort Worth, Houston-Galveston, and San Antonio. The Trinity River below Dallas is dominated by treated sewage during summer months. A similar situation exists in the San Antonio River below the San Antonio metropolitan area. In the Houston-Galveston metropolitan area, water quality problems are increasing with increasing urban and industrial development.

Serious flooding conditions have at one time or another struck most parts of the State. Flash flooding resulting from high-intensity rainstorms is common and not easily predicted. Also, the flat coastal

area is vulnerable both to high tides and to heavy runoff from rainfall associated with tropical storms. In the coastal area, and in other parts of the State, the flat land surface is not particularly amenable to flood control by structural measures.

The potential effects of upstream water development on freshwater inflows to the bays and estuaries are of major concern to the State. Use of the bays for navigation, commercial shell dredging, commercial and sport fishing, oil and gas production, maintenance and propagation of marine life, and diverse recreational ues is extensive. These activities make a major contribution to the viability of the State's economy. Estimates of the freshwater inflows needed for estuarine purposes, along with estimates of fresh water needed for other purposes, are included in the amended plan.

The location of existing water supplies in relation to the areas of water need presents a significant water resource planning problem. In many areas, El Paso, the Texas High Plains, and the Lower Rio Grande Valley, for example, where existing ground-water supplies are beginning to be depleted, or where demands are beginning to exceed current surface-water supplies, there are no supplemental supplies available, except at great distances. This problem is compounded by limited availability and poor characteristics of dam and reservoir sites. Thus, supplemental water supplies, either surface or ground, may have to be transported great distances to meet future demands.

The major types of water and water-related problems in each of eight major geographic regions of the State are described below.

Upper Rio Grande and the Far West Texas Region:

1. Water supplies are very limited. The surface-water and ground-water supplies of the region are shared by Texas, New Mexico,

and Mexico. During the past 30 years, the Rio Grande delivered only 65 percent of the water needed for the El Paso irrigation area.

2. High salinity in surface-water supplies due to frequent low flows, and increased salinity of municipal and agricultural return flows is detrimental to crops and cropland.

3. Ground water from the Hueco Bolson deposits is the primary source of municipal and industrial supply. The Bolson is being "mined" and saline water from adjacent saline water-bearing sands is encroaching upon the Bolson.

4. Fresh ground water is projected to meet El Paso's needs through 2010, but at higher costs for pumping and a poorer quality water.

5. Water supply for smaller cities is a problem now.

6. Flash flood is a major problem.

Major cities - El Paso

High Plains and Trans-Pecos Region:

1. Surface-water supplies are very scarce, with practically all such supplies already developed and dedicated.

2. The High Plains (Ogallala) Aquifer - the major source of municipal and irrigation water is being overdrafted. At the present time, the Ogallala supplies irrigation water to 4.6 million acres in the Southern High Plains (south of Canadian River) and 1.3 million acres in the Northern High Plains. By the year 2000, it is projected that the Ogallala can supply irrigation water to 7.5 million acres if an effective water conservation program is implemented and 6.0 million acres if effective conservation is not practiced throughout the area. By the year 2030, it is projected that the Ogallala can supply water to irrigate only 1.8 million acres (39 percent of the present acres) and

0.9 million acres (72 percent of present acres) in the Southern and Northern High Plains, respectively, if an effective water conservation program is not implemented.

3. Municipal and industrial water supplies are becoming more difficult to obtain and more expensive as the water table declines. Some major cities of the area will need additional supplies by 1990. Ground water in many areas is higher in fluoride and nitrate concentrations than the state allows for public consumption under the Federal Safe Drinking Water Act.

4. Localized flooding is a problem throughout the Region.

Major Cities: Odessa, Midland, Lubbock and Amarillo

West Texas Region:

1. Surface-water and ground-water supplies are very scarce.

2. Natural salt pollution in the upper reaches of the Red and Brazos River Basins precludes full utilization of the water resources of these basins. Also, leaking oil, gas, and salt water disposal wells and improper disposal of salt water incidental to oil and gas exploration and production have resulted in local contamination of fresh ground and surface-water supplies.

3. High nitrate concentrations occur in the ground water in some areas due to natural phenomena, locally intensified by septic tanks, cesspools, feedlots, agricultural fertilizers, and cultivation practices. Locally, ground water is higher in fluoride than existing State standards for public consumption under the Federal Safe Drinking Water Act.

4. Major cities will need additional supplies within the next 25 to 30 years. Some smaller cities have experienced water

shortages during droughts since 1980, and as a rule have poor quality water (relatively high chloride, fluoride, dissolved solids, and nitrate concentrations).

5. Brush infestation of rangeland and growth of woody species that obtain water directly from the water table or from the soils just above it (phreatophytes) compete with more useful plants for fresh water.

6. Agricultural land practices in some dryland farming areas cause increased infiltration of water directly from rainfall and from surface runoff. This has contributed to soils becoming water logged, highly mineralized, and completely unproductive.

7. Localized flooding is a problem throughout the Region.

Major Cities: Abilene, Wichita Falls

North Texas Region:

1. Surface-water development is near the maximum potential for the Upper Trinity River Basin. Water is being imported from neighboring basins to the east. Potential future surface-water projects to serve the region are located in neighboring basins to the east and the north.

2. Major cities have adequate supplies to meet projected needs until about 2000 to 2010. Cities served by the North Texas Municipal Water District are near critical water supply conditions.

3. Ground-water levels (Trinity Group Aquifer) have been lowered severely; thus, pumping costs are burdensome and will increase.

4. Quality of ground water is deteriorating as water levels decline. Fluoride concentrations of ground water are high. Surface-water quality suffers from high urban use pressures (dissolved oxygen, suspended solids, phosphates, fecal coliform, algal blooms, and aquatic

plants).

5. Smaller cities throughout the area do not have adequate supplies to meet growth needs. Many are barely meeting current needs.

6. Major flooding problems exist in the region.

7. High chloride concentrations in Lake Texoma in the Red River Basin and reservoirs in the middle Brazos River Basin preclude full utilization of the water resources of these basins.

Major Cities: Dallas, Fort Worth, Waco, Arlington, Denison, Garland, Killeen, Temple, Sherman, Denton, Plano, Richardson, Irving

Northeast Texas Region:

1. Surface-water and ground-water resources are potentially available to meet projected needs, if projects are planned and developed on schedule.

2. Rapid growth due to development and use of lignite reserves is expected.

3. Water and air quality protection and land reclamation from strip mining are potential problems for this area.

4. In many areas, shallow ground water has high concentrations of iron and is acidic, which makes the water undesirable for municipal use and many manufacturing processes. These problems generally can be solved by completing wells in deeper water-bearing sands or by expensive treatment of water from shallow wells.

5. Presently, water supplies for many smaller cities are inadequate in both quality and quantity.

6. Flooding problems are present in local areas.

7. Periodically, dissolved oxygen content in streams is low due to low stream flow and low natural reaeration rates.

Major Cities: Tyler, Longview, Texarkana, Marshall

South Central Texas Region:

1. Rapid growth of cities and suburban areas is straining existing water supply and waste disposal facilities and subjecting many citizens to threat of flooding.

2. Development of surface-water projects is needed to firm up municipal supplies and reduce reliance on the Edwards (Balcones Fault Zone) Aquifer in critical drought periods. Increased use of surface water would also assist in maintaining the ecosystems and recreational opportunities of Leona, San Pedro, San Antonio, Hueco, Comal, and San Marcos Springs, and the base flow of streams to the south of the aquifer.

3. Continued protection of the Edwards (Balcones Fault Zone) Aquifer from pollution is essential.

4. Pumping from the Carrizo Aquifer in the Winter Garden area has lowered water levels more than 400 feet since 1930. Poor quality water is encroaching into the aquifer in this area. Pumping costs may soon render this aquifer an uneconomic source of irrigation water.

5. The Guadalupe, San Antonio, and lower Colorado River Basins have potential surface-water projects that can be developed.

6. The upper Colorado River Basin has serious water quality problems due to inflow of saline ground water.

7. The region has other local salinity problems and flooding problems from locally intense storms.

Major Cities: Austin, San Antonio, San Angelo

South Texas and Lower Gulf Coast Region:

1. The Region has insufficient quantities of surface water and ground water to meet growth needs for all water-using purposes.

Surface-water supplies are practically all developed and committed. During extended drought periods, some of the current requirements cannot be met.

2. Soil salinity and drainage problems are present locally.

3. Flooding and storm surge problems exist.

4. Woody species that obtain water from the water table or from the soils just above it (phreatophytes) compete with more useful plants for water.

5. Surface-water quality in the region is generally good, but low dissolved oxygen occurs in some stream segments during summer months.

6. Navigation facilities, channel maintenance, dredge spoil disposal, and bay and estuary protection require continuing management programs.

Major cities: Brownsville, Kingsville, Laredo, McAllen, Harlingen, Corpus Christi

Southeast Texas and Upper Gulf Coast Region:

1. Land surface subsidence and salt water encroachment result from overdevelopment of ground-water supplies.

2. The Houston and Galveston areas have water supplies to meet growing needs until 1990 to 1995.

3. Smaller cities are having problems from lack of surface-water availability and insufficient treatment, conveyance, and storage facilities.

4. Storm surge flooding and drainage problems are present.

5. Salt water intrusion during periods of low flow in the Brazos, Neches, and Trinity Rivers has the potential for contaminating

the freshwater supply at existing intake facilities.

6. Navigation facilties, channel maintenance, dredge spoil disposal, and bay and estuary protection require continuing management programs.

7. Water quality problems require a continuing management program.

Major Cities: Houston, Galveston, Beaumont, Port Arthur, Victoria, Bryan, College Station, Lufkin, Nacogdoches, Huntsville, Orange

The conditions described above are illustrative of the types of water problems present in major geographic areas of Texas. However, it is emphasized that each area has significant water resources and water resource facilities that are now being used. These problems have been identified for the purpose of developing and suggesting plans to solve as many of them as possible.

More than 50 percent of Texas is underlain by seven major aquifers and sixteen minor aquifers. Collectively, these aquifers receive an average annual natural recharge of about 5.3 million acre-feet (one acre-foot of water equals 325,851 gallons) and contain about 430 million acre-feet of water in storage that is recoverable using conventional water well technology. Of this total, about 89 percent, or 385 million acre-feet, is in the High Plains (Ogallala) Aquifer. Of the 17.9 million acre-feet of water that Texans currently use annually, about 10.9 million acre-feet is from ground-water sources. Of the 10.9 million acre-feet of ground water used, 11.9 percent, or 1.3 million acre-feet, is for municipal purposes; 249 thousand acre-feet, is for manufacturing purposes; 0.5 percent, or 53 thousand acre-feet, is for steam-electric power generation; 1.7 percent, or 183 thousand acre-

feet, is for mining; 1.1 percent, or 120 thousand acre-feet, is for livestock watering; and 82.5 percent, or 8.9 million acre-feet, is for irrigation. About 50 percent of municipal water is obtained from ground-water sources. Ground water is used for municipal purposes in all areas of Texas and in practically every county. However, in many areas, the long-term use of ground water is lowering water levels to the extent that major water supply problems are occurring, or are projected to occur, in the forseeable future.

Texas has 15 major river basins and eight coastal basins that have approximately 3,700 designated streams and tributaries and more than 80,000 miles of streambed, 16,000 miles of which are subject to specific numerical water quality criteria established and adopted by the Department of Water Resources in cooperation with the U.S. Environmental Protection Agency. Long-term average annual precipitation ranges from 8 inches in the El Paso area to more than 56 inches in the Beaumont area. Average annual runoff (streamflow) is about 49 million acre-feet. Runoff ranges from about 1,100 acre-feet per square mile at the Texas-Louisiana border to practically zero in parts of the Trans-Pecos Region of far West Texas. From 1940 through 1970, statewide runoff averaged 57 million acre-feet per year during the wettest period (1940-1950), and 23 million acre-feet per year during the severe drought of the early and mid-1950's.

There are currently 184 major reservoirs (36 federal and 148 non-federal) with 5,000 acre-feet or greater total capacity in Texas. In addition, there are five reservoirs presently under construction (four federal and one non-federal). Conservation storage capacity in existing major reservoirs and those under construction totals about

32.3 million acre-feet. Flood control storage capacity totals about 17.5 million acre-feet. The dependable (firm) water supply - the uniform yield that can be withdrawn annually from conservation storage through extended drought periods - from major reservoirs is about 11 million acre-feet annually. Texans now use about 7 million acre-feet (64 percent) of this dependable surface-water supply. A little over 21.7 percent is for municipal uses, 18.2 percent is for manufacturing purposes, 3.9 percent is for stream-electric power generation, 0.8 percent is for mining, 1.8 percent is for livestock watering, and 53.5 percent is for irrigation. A large portion of the remaining 4.0 million acre-feet of dependable surface-water supply is committed through permits and contracts to meet growing municipal and industrial needs of major metropolitan areas of the state over the next 30 years. This supply, however, will not meet all of the projected municipal and industrial needs of many Central, South, North Central, and West Texas cities. It is also projected that many cities in the eastern part of the state will need to develop additional surface-water supplies in the near future.

3.2 The Rocky Creek Story

In the late 1950's landowners on five ranches, covering about half the 74,000 acre West Rocky Creek watershed, began rootplowing, reseeding, treedozing, aerial spraying, and chaining. The ranchers received technical assistance and cost-sharing for this work through the Great Plains Conservation Program. The program is administered through local soil and water conservation districts in selected Great Plains counties by USDA's Soil Conservation Service. These ranchers did not start out to prove anything - it just happened.

West Rocky Creek flowed yearlong until the drought of 1918-1919, when it became an intermittent stream. By 1935, springs feeding the creek had been dried up by mesquite and other invading woody plants.

Located in the Edwards Plateau region, West Rocky Creek is a tributary of the Middle Concho about 20 miles west of San Angelo. Average annual precipitation is about 18 inches. Shallow soils formed over limestone and caliche are characteristic of the plateau regions, and early day travelers described the rough, rolling hills as barren. The only timber was along the draws and the need for firewood was a real concern to these pioneers.

Before the area was settled, prairie fires were common - set naturally by thunderstorms and also by Indians. Early travelers reported seeing prairie fires that would burn for miles prior to being extinguished by either a lack of fuel or by rainfall. Fires suppressed the brush. As the early pioneers began to fence the rangeland, several things happened. Their apparent lack of understanding about grazing management depleted the cover of prairie grass such as sideoats grama, the state grass of Texas. In pristine condition, most of the watershed supported a plant cover averaging 2,000 pounds of production per acre which was mostly grasses.

Settling of the land stopped the wildfire because the settlers fought them and because there was no longer enough grass to burn. This lack of ground cover allowed erosion to take place and held little water on the land. Not only did the reduced ground cover short circuit the aquifer recharge cycle but it provided a favorable environment for the establishment of brush plants. The brush first encroached on the deeper soils and then gradually moved up the draws to the hillsides. The watershed now would support only about 500 pounds per acre of

protective grasses.

Mesquite was the main brush problem. With its extensive root system it could draw water from far below the 5 foot depth that is generally the limit for native grasses such as sideoats grama, buffalograss, curly mesquite, and tobosa. It is interesting to note that scientists estimate that 38 percent of the rainfall in Texas is used by non-economic plants. This equates to about 138 million acre feet per year.

In 1964, following the accelerated range conservation program, one of the five ranchers noticed that a spring - dry since 1935 - had started flowing again. By replacing the water hungry brush with a good grass cover, more rainfall soaked into the aquifer, recharging the dormant springs. By 1970, springs had begun flowing on all five ranches. West Rocky Creek, which now flows at a rate of 475 to 4,000 gallons per minute is not big by most standards but its sparkling waters are a welcome sight in West Texas. All the conservation work was done in a manner that would benefit white-tailed deer and turkey, which are a valuable hunting resource.

The role of sound grazing management cannot be overlooked. The ongoing grazing management on each ranch enhances the cover of grasses on the watershed. The soils now, under good grazing management, are producing an estimated 2,000-2,500 pounds of mostly grass forage per acre.

This grass cover retards the re-invasion of brush and helps hold water and soil on the land. The turf decreases the sediment load in surface water supplies. Sediments reduce water quality and the storage capacity of reservoirs and streams. Although the brush succession is retarded, these ranchers periodically must do maintenance brush control

to prevent reinvasion.

Even though the rangeland improvements have reduced erosion in the watershed and increased forage production for the ranchers' livestock, the story of West Rocky Creek may be more important to the 70,000 residents of San Angelo. Water from the creek supplements the city's water supply reservoirs. Currently, water in San Angelo homes costs $3.05 for the first 2,00 gallons and $0.67 for each 100 gallons thereafter. The West Rocky Creek Watershed yields an estimated 525,600,000 gallons annually. If water costs are calculated at $1.50 per 1,000 gallons, the West Rocky Creek Watershed yields $788,400 of clear water annually. In other words, each acre of the West Rocky Creek Watershed yields approximately $10.63 worth of water annually.

West Rocky Creek now contributes approximately 7% of San Angelo's total water needs. Its watershed occupies 3% of the entire watershed that supports the municipal and recreation supplies of San Angelo.

If the West Rocky Creek treatment were expanded to the entire watershed above San Angelo, one could predict a long lasting supply of clear water, increased livestock production and decreased sedimenation of downstream water supplies. Subsequent impacts to wildlife should be minor.

3.3 Available Technology on the Subject

As indicated in initial investigations by the State Soil and Water Conservation Board, very little documented research work has been done in Texas on relationships between vegetative manipulation on rangeland and water yield from that rangeland. Examples such as Rocky Creek west of San Angelo combined with research data from other states has given rise to the logical assumption that in areas where the

potential exists, increased water yield through brush management and sound conservation is possible.

The following comments by Dr. Will Blackburn, Department of Range Science, Texas A&M University do an excellent job of summarizing current thinking: Texas rangeland watersheds provide most of the state's water. Recharge areas for the state's major aquifers such as Trinity, Edwards-Trinity, Edwards, Carrizo-Wilcox and Gulf Coast are primarily rangeland watersheds. Likewise, more than 60% of the surface flow in rivers is from rangeland watersheds. Cities such as Dallas, Fort Worth, Wichita Falls, Waco, Temple, Austin, San Antonio, Corpus Christi and many others are directly dependent on range watersheds for their water. These are also the areas where water shortages are projected.

Water yields can be increased in these areas by removing shrubs and trees that intercept and transpire large amounts of water, and replace them with grasses that require less water. The relationships between plant, soil, water and land use have been studied for many years on range and forest lands. Controversy over the role of forests in the water balance resulted in the now-famous Wagon Wheel Gap Study in Colorado, in which streamflow was shown to increase when aspen, spruce and fir trees were cut on one of a pair of instrumented watersheds (Bates and Henry, 1928). The idea of improving water yield by vegetation management on rangelands began to receive attention in water short areas by the early 1950's (Barr, 1956).

Water Balance

A simple water balance model can be expressed by:

$$\text{Water Yield} = P - ET - \Delta S$$

Where: Water yield = surface and subsurface flows, and any percolation to ground water
P = precipitation
ET = evapotranspiration, including interception losses by vegetation and litter
ΔS = change in soil water storage

If ET can be reduced by altering the vegetation, water yield must increase by an equal amount, minus any increase in stored water. The opportunity to reduce evapotranspiration effectively is limited to certain types of vegetation and climate. The following conclusions are based on a review of the literature in rangeland hydrology and watershed management research (Hibbert 1983):

1. Annual precipitation should exceed 15 inches. Bosch and Hewlett (1982) demonstrated from a worldwide review of 94 watershed studies a positive linear relationship of water yield to precipitation. No water yield response to vegetation manipulation occurred in areas receiving less than 16 to 18 inches of mean annual precipitation. Maximum water yield efficiency occurred when precipitation was concentrated during the cool season.

2. Vegetation must be replaceable with plants that use less water. Replaceable plants that meet these criteria best are deep-rooted with large biomass that intercept and transpire large amounts of water. Replacement species should be low in biomass, deciduous or dormant much of the time, and shallow-rooted.

3. It may not be practical and is usually not desirable to eradicate all high water-use plants. However, they must be thinned sufficiently that roots of the remaining plants do not deplete the

water savings (Figure 1).

Potential for Increasing Water Yield From Arizona and California Chaparral

A large percentage of Texas brushlands meet the above criteria quite well. However, little or no research has been conducted in Texas to substantiate findings in other western states. Considerable research has been conducted in Arizona and California Chaparral regions on the potential of water yield improvement by vegetative management. Even though chaparral-dominated brushland is similar to the kinds of brushland found in Texas, the climate, soil, geology, topography and shrub species involved are generally different. Accurate water yield estimates in Texas cannot be based on data collected in Arizona and California; they must be determined by research in Texas.

Chaparral watershed experiments in Arizona and California demonstrated that mean annual streamflow can be increased by as much as 6 inches by converting brush-dominated watersheds to grass. Precipitation was found to be of major inportance in water yield response to vegetative conversion (Figure 2). In spite of the limitations imposed by the large variation in treatment results (r^2 = 0.55), two conclusions can be made that should help in management of Texas brushlands for increased water (Hibbert 1983).

1. There is no potential for increasing water yield where precipitation averages less than 16 inches per year and increases are likely to be marginal between 16 and 20 inches of precipitation.

2. Water yield increases will increase by approximately 1 inch for each 4 inch increase in precipitation above the 16 inch "threshold" value.

Potential for Increasing Water Yield from Texas Rangelands

The Soil Conservation Service in Texas has estimated that ten million acre feet of water could be yielded annually by a comprehensive brush management program (Rechenthin and Smith 1967). These estimates (Table 1) were made by river basin and are heavily based on research data from chaparral watersheds in Arizona and California. The greatest potential for increasing water yields are in the Red, Brazos, Colorado and Nueces watersheds. Some may argue that these estimates are too high or too low but we must recognize that such a vegetation management program will yield large quantities of needed water. Just how much could be saved is somewhat difficult to estimate since there is so little research available from Texas on water consumption by shrubs. However, these estimates are the best available, considered conservative by those who made them and can only be improved by research conducted in Texas. Figure 3 shows the estimates of how much water could be saved by controlling brush on upland watershed areas in various parts of the state.

Table 1. Estimated water saved by major watershed (from Rechenhin and Smith (1967).

Name of Watershed	Acre-feet Water
Canadian	413,400
Red	1,386,700
Brazos	2,035,800
Colorado	1,909,900
Trinity	704,000
Sabine-Neches	291,200
San-Jacinto	49,400
Rio Grande-Pecos	799,700
Nueces	1,121,700
Guadalupe-San Antonio	646,200
Other areas:	
High Plains	292,000
Gulf Coast intervening areas	594,800
TOTAL	10,244,900

3.4 Research Needs

Research on brush control/water enhancement is one of the most important aspects of a continuing brush control program. As pointed out in Section 3.3, very limited research data is available. While we have examples of water yield improvement through brush control, we have very little hard data useful in reproducing these examples. Traditionally brush control on rangeland is carried out to increase production and improve efficiency. Some work has been done to improve efficiency. Some work has been done to improve wildlife habitat or to enhance asthetic beauty. The fact that springs started flowing after the work was completed was incidental to the main purpose. Therefore nearly all of the research on brush control has been directed toward improving production.

Currently several research projects on various aspects of brush control for water enhancement are being initiated. Texas Agricultural Experiment Station, USDA-Agricultural Research Service, Texas Tech University and the Ceasar Kleberg Wildlife Research Institute all either have projects underway or have proposed projects awaiting funding.

There are four basic areas which require intensive research if we are to truly understand all of the interrelationships associated with vegetative manipulation for water enhancement on rangeland.

1. Determine the water use efficiency of native brush and grass species under various management systems.

2. Determine the impact of various range management strategies on water-use efficiency, water yield, soil erosion, and water quality.

3. Accurately define favorable areas for brush control and

grassland restoration where subsequent increases in water yield would occur.

4. Determine trade-offs between various levels of brush removal and wildlife populations.

Section IV. S. B. 1083 - The Brush Control Bill

4.1 List of Key Points

Creates the Texas Brush Control Program

Gives responsibility for the program to Texas State Soil & Water Conservation Board

203.001 defines "Brush Control" - includes control and revegetation

203.012 - the board shall adopt reasonable rules that are necessary to carry out this chapter

203.013 responsibilities may be delegated to districts

203.016 - the board shall consult the Parks and Wildlife Department

203.051 - the board shall prepare and adopt a state brush control plan

203.052 - the board shall hold a hearing on the proposed plan

203.053 - criteria for designating critical areas (must give priority to areas with most critical water needs with highest potential for substantial water conservation)

203.054 - must review plan every two years

203.055 - the board must approve all methods used to control brush under the act

203.056 - the board must report to the governor, speaker, and lieutenant governor on the activities of the program during the previous year

203.102 - the board shall prepare and distribute information to each district concerning procedures for preparing, filing, and obtaining approval of an application for cost sharing assistance

203.103 - districts may accept and comment on applications for cost sharing. After review, the district shall submit to the board the application and comments

203.104 - districts can inspect and supervise projects within their jurisdiction on behalf of the board

203.151 - creates cost share program

203.152 - creates the "Brush Control Fund"

203.154 - limits state's portion of cost share to 70 per cent

203.155 - cost sharing is available only in designated critical areas using approved methods

203.156 - individual application for cost sharing

203.175 and 203.158 - board approval of individual applications

203.160 - the board or a designated district shall negotiate contracts with successful applicants

203.161 - districts may administer state money as required by a cost share contract

4.2 Responsibilities of the State Board Under S. B. 1083

1. The board has jurisdiction over and shall administer the brush control program

2. The board shall adopt reasonable rules that are necessary to carry out the program

3. The board shall consult with the Texas Parks and Wildlife Department

4. The board shall prepare and adopt a State Brush Control Plan

    a) must include a comprehensive strategy for managing brush in those areas where brush is contributing to a substantial water conservation problem
    b) must designate areas of critical need in the State

5. The board shall hold a hearing on the proposed plan

6. Shall review the plan every two years

7. Must report to the governor, speaker and lieutenant governor on the activities of the program during the previous year

8. Must approve all brush control methods used under the program

9. Shall prepare and distribute all the information necessary for participation in the program to all districts

10. If the demand for cost share funds is greater than funds available, the Board may establish priorities favoring the most critical areas that would have the greatest water conservation benefits

11. The board or a district delegated by the board is responsible for receiving and approving individual applications for cost share assistance

12. The board or a designated district shall negotiate contracts with successful applicants

13. The board or a designated district must certify that the work to be cost shared has indeed been completed before the state's share of the cost is paid

14. The state or a designated district must administer state money as required by a cost share contract

4.3 Texas Brush Control Bill

An act relating to the creation, implementation, administration, operation, and financing of the Texas Brush Control Program under the jurisdiction of the State Soil and Water Conservation Board and to powers and duties of the board; adding Chapter 203 to Title 7, Agriculture Code.

Be it enacted by the Legislature of the State of Texas:

Section 1. Title 7, Agriculture Code, as amended, is amended by adding Chapter 203 to read as follows:

Chapter 203. Brush Control
Subchapter A. General Provisions
Section 203.001. Definitions. In this chapter:

(1) Board means the State Soil and Water Conservation Board.
(2) District means a soil and water conservation district created under Chapter 201 of this code.
(3) District board means the board of directors of a soil and water conservation district created under Chapter 201 of this code.
(4) Brush control means:
(A) the selective control, removal, or reduction of noxious brush such as mesquite, prickly pear, salt cedar, or other phreatophytes that consume water to a degree that is detrimental to water conservation; and
(B) the revegetation of land on which this brush has been controlled.
(5) Critical area means an area of critical need designated by the board under the plan for the brush control program.

Section 203.002. Creation of Program

The Texas Brush Control Program is created and shall be implemented, administered, operated, and financed as provided by this chapter.

(Sections 203.003-203.010 reserved for expansion)

Subchapter B. Administrative Provisions

Section 203.001. Authority of Board

The board has jurisdiction over and shall administer the brush control program under this chapter.

Section 203.012. Rules

The board shall adopt reasonable rules that are necessary to carry out this chapter.

Section 203.013. Authority of Districts

Each district in which all or part of a critical area is located may carry out the responsibilbities provided by Subchapter D of this code as delegated by the board in that critical area.

Section 203.014. Personnel

The board may employ or contract with any person necessary to assist the board or a district to carry out this chapter.

Section 203.015 Expenditures

In addition to any other expenditures authorized by this subchapter, the board may make expenditures provided by the General Appropriations Act.

Section 203.016 Consultation

The board shall consult the Parks and Wildlife Department in regard to the effects of the brush control program on fish and wildlife.

(Sections 203.017-203.050 reserved for expansion)

Subchapter C. General Powers and Duties of Board

Section 203.051. State Plan

The board shall prepare and adopt a state brush control plan that shall:

(1) include a comprehensive strategy for managing brush in areas of the state where brush is contributing to a substantial water conservation problem; and

(2) designate areas of critical need in the state in which to implement the brush control program.

Section 203.052. Notice and Hearing

(a) Before the board adopts the plan under Section 203.051 of this code, the board shall call and hold a hearing to consider a proposed plan.

(b) Not less than 30 days before the date the hearing is to be held, the board shall mail written notice of the hearing to each district in the state. The notice must include the date and place for holding the hearing and must state the purpose for holding the hearing.

(c) At the hearing, representatives of a district and any other person may appear and present testimony including information and suggestions for any changes in the proposed plan.

(d) After the conclusion of the hearing, the board shall consider the testimony including the information and suggestions made at the hearing and, after making any changes in the proposed plan that it finds necessary, the board shall adopt the plan.

Section 203.053. Criteria for Designated Critical Areas

(a) In designating critical areas under the plan, the board shall consider:

(1) the location of various brush infestations;

(2) the type and severity of various brush infestations;

(3) the various management methods that may be used to control brush; and

(4) any other criteria that the board considers relevant to assure that the brush control program can be most effectively, efficiently, and economically implemented.

(b) In designating critical areas, the board shall give priority to areas with the most critical water conservation needs and in which brush control and revegetation projects will be most likely to produce substantial water conservation.

Section 203.054. Amending Plan

At least every two years the board shall review and may amend the plan to take into consideration changed conditions. Amendments to the plan shall be made in the manner provided by this chapter for adopting the original plan.

Section 203.055. Approved Methods for Brush Control

(a) The board shall study and must approve all methods used to control brush under this Act considering the overall impact the project will have within critical areas.

(b) The board may approve a method for use under the cost-sharing program provided by Subchapter E of this chapter if the board finds that the proposed method:

(1) has proven to be an effective and efficient method for controlling brush;

(2) is cost efficient;

(3) will have a beneficial impact on the wildlife habitat;

(4) will maintain topsoil to prevent erosion or silting of any river or stream; and

(5) will allow the revegetation of the area after the brush is removed with plants that are beneficial to livestock and wildlife.

Section 203.056. Report

(a) Before January 31 of each year, the board shall submit to the governor, the speaker of the house, and the lieutenant governor a report of the activities of the brush control program during hte immediately preceding calendar year.

(b) The board may make copies of this report available on request to any person and may charge a fee for each report that will allow the board the recover its costs for printing and distribution.

(Sections 203.057-203.100 reserved for expansion)

Subchapter D. Powers and Duites of Districts

Section 203.101. General Authority

Each district may administer the aspects of the brush control program within any critical area located within the jurisdiction of that district.

Section 203.102. Provide Information Relating to Program

The board shall prepare and distribute information to each district relating generally to the brush control program and concerning the procedures for preparing, filing, and obtaining approval of an application for cost sharing under Subchapter E of this chapter.

Section 203.103. Acceptance and Comment on Application

(a) Each district may accept for transmission to the board applications for cost sharing under Subchapter E of this chapter and may examine and assist the applicant in assembling the application in proper form before the application is submitted to the board.

(b) Before a district submits an application to the board, it shall examine the application to assure that it complies with rules of the board and that it includes all information and exhibits necessary for the board to pass on the application.

(c) At the time that the district examines the application, it shall prepare comments and recommendations relating to the application and the district board may provide comments and recommendations before they are submitted to the board.

(d) After reviewing the application, the dsitrict board shall submit to the board the application and the comments and recommendations.

Section 203.104. Supervision of Projects

(a) Each district on behalf of the board may inspcct and supervise projects within its jurisdiciton in which state money is provided under Subchapter E of this chapter.

(b) Each district board exercising the duties under Subsection (a) of this section shall periodically report to the board relating to this inspection and supervision in the manner provided by board rules.

(c) The board may direct a district to manage any problem that arises under a cost-sharing contract for brush control in that district and to report to the board.

(Sections 203.106-203.150 reserved for expansion)

Subchapter E. Cost Sharing for Brush Control

Section 201.151. Creation of Cost-Sharing Program

As part of the brush control program, a cost-sharing program is created to be administered under this chapter and rules adopted by the board.

Section 201.152. Brush Control Fund

(a) The brush control fund is a special fund created in the State Treasury to be used as provided by this subchapter.

(b) The brush control fund consists of legislative appropriations, money tranferred to that fund from other funds by law, and other money required by law to be deposited in the brush control fund.

Section 203.153. Use of Money in Brush Control Fund

Money deposited to the credit of the brush control fund shall be used by the board to provide the state's share of the cost of brush control projects approved under this subchapter and other necessary expenditures as provided by the General Appropriations Act.

Section 203.154. Limit on Cost-Sharing Participation

(a) Not more than 70 percent of the total cost of a single brush control project may be made available as the state's share in cost sharing.

(b) A person is not eligible to participate in the state brush control program or to receive money from the state brush control program if the person is simultaneously receiving any cost-share money for brush control on the same acreage from a federal government program.

(c) The board may grant an exception to Subsection (b) of this section if the board finds that joint participation of the state brush control program and any federal brush control program will:

(1) enhance the efficiency and effectiveness of a project; and

(2) lessen the state's financial commitment to the project.

Section 203.155. Limit to Critical Areas and Approved Methods

Cost charing under this subchapter is available only for projects that:

(1) are implemented in critical areas as designated by the board; and

(2) use a method of brush control approved under Section 203.055 of this code.

Section 203.156. Application for Cost Sharing

A person who desires to participate with the state in a brush control project and to obtain cost-sharing participation by the state shall file an application with the district board in the district in which the land on which the project is to be accomplished is located. The application must be in the form provided by board rules.

Section 203.157. Considerations in Passing on Application

In passing on an application for cost sharing, the board shall consider:

(1) whether the project is to be carried out in a critical area;

(2) the method of control that is to be used by the project applicant;
(3) the plans for revegetation;
(4) the total cost of the project:
(5) the amount of land to be included in the project;
(6) whether the applicant for the project is financially able to provide his share of the money for the project;
(7) the cost-share percentage, if an applicant agrees to a higher degree of financial commitment;
(8) any comments and recommendations of the Parks and Wildlife Department; and
(9) any other pertinent information considered necessary by the board.

Section 203.158. Approval of Application

The board may approve an application if, after considering the factors listed in Section 203.157 of this code and any other relevant factors, the board finds:
(1) the owner of the land fully agrees to cooperate in the project;
(2) the method of eradication is a method approved by the board under Section 203.055 of this code; and
(3) the project is to be carried out in a critical area designated under the board's plan.

Section 203.159. Priority of Projects

(a) If the demand for funds under the cost-sharing program is greater than funds available, the board may establish priorities favoring the areas with the most critical water conservation needs and projects that will be most likely to produce substantial water conservation.
(b) The board shall give more favorable consideration to a particular project if the applicants idividually or collectively agree to increase the percentage share of costs under the cost-share arrangement.
(c) The amount of land dedicated to the project that will produce significant water conservation from the eradication of brush is a priority.

Section 203.160. Contract for Cost Sharing

(a) On approval of an application by the board, the board or the governing board of the designated district shall negotiate contracts with the successful applicants in the project area.
(b) The board or designated district board shall negotiate a contract with the successful applicant subject to:
(1) the conditions established by the board in approving the application;
(2) any specified instructions provided by the board; and
(3) board rules.
(c) On completion of the negotiations by the district board, it shall submit the proposed contract to the board for approval.
(d) The board shall examine the contract and if the board finds

that the contract meets all the conditions of the board's resolution, instructions, and rules, it shall approve the contract and provide to the individual on completion of the project the money that constitutes the state's share of the project.

(e) The board may develop guidelines to allow partial payment of the state's share of a brush control project as certain portions or percentages of contracted work are completed, but state money may not be provided in advance for work remaining to be done.

Section 203.161. Administration of Expenditures

The district board may administer expenditure of the state's share of the money required by a cost-sharing contract and shall report periodically to the board on the expenditure of those funds in the manner required by the board.

Section V. Delineation of Critical (High Potential) Areas

5.1 1983 USDA - Soil Conservation Service Brush Survey

The survey will be used to show on a statewide basis where various brush species and densities exist. As most current information is made available on brush infestation, especially at the county level, it will be included in the plan. When combined with water supply and demand and potential water yield information, certain areas in the state will emerge as having the highest potential for the program. This delineation is not meant to pick out specific projects, but rather to set general boundaries. Because of the many other factors involved in developing a successful project such as willingness of the local people to participate, landowner cooperation, social and economic considerations, and wildlife concerns, project applications must come from the local level.

Another source of information on the brush problem to be used in delineating critical areas is the long range conservation plan developed for the state by the State Soil and Water Conservation Board. This publication, Soil and Water Conservation: The Texas Approach includes a 1981 survey of all the conservation districts in the state on various conservation problems. The survey includes categories for ranking problems, determining present severity, and listing possible solutions on a district-by-district basis. Undesirable brush and weeds was ranked by 148 out of 201 districts as one of their five most critical problems. Thirty nine percent of the rangeland in the state was listed as having a moderate problem and 37 percent was listed as having a severe problem. This means that districts have identified 76 percent of the rangelands in Texas as having significant amounts of

% Canopy	Creeping Mesquite Acres	Honey Mesquite Acres	Blueberry Juniper Acres	Redberry Juniper Acres	Sand Shinoak Acres
1	60,400	3,613,700	470,400	1,218,700	70,200
1-5	110,300	17,795,900	3,012,000	4,621,600	458,400
6-10	74,100	10,508,300	1,622,400	2,728,900	393,000
11-20	58,600	9,873,400	1,401,600	1,882,800	463,200
21-30	61,300	4,739,700	794,700	818,000	378,900
31-50	33,100	2,790,900	732,800	358,200	415,500
51-75		1,036,700	473,500	91,000	257,200
76-100		408,500	148,300	8,500	78,600

% Canopy	Post Oak Acres	Prickleypear Acres	Broom Snakeweed Acres	Blackbrush Acres	Creosotebush Acres	Huisache Acres
1	232,700	5,643,900	987,300	373,200	511,300	251,100
1-5	1,293,900	19,881,300	4,039,200	2,047,600	3,180,200	1,468,000
6-10	1,065,200	3,276,300	2,443,000	1,806,000	2,368,300	712,100
11-20	1,131,800	1,398,000	1,633,300	1,413,300	2,635,500	502,000
21-30	842,100	300,500	548,800	790,000	841,600	179,500
31-50	942,600	146,800	269,300	463,200	313,200	142,900
51-75	619,900	21,700	53,200	121,000		64,100
76-100	221,500	7,500	13,000	37,800		9,800

% Canopy	Macartney Rose Acres	Whitebrush Acres
1	47,500	674,600
1-5	152,300	2,477,100
6-10	71,400	1,120,000
11-20	48,200	645,500
21-30	22,000	290,900
31-50	4,200	146,500
51-75	19,800	70,900
76-100	3,400	22,500

	Improvement With Brush Management	Brush Management and Reestablishment
Trans-Pecos	3,129,400	683,500
High Plains	1,767,900	199,600
Rolling Plains	5,439,900	1,182,200
Rolling Red Prairies	190,800	72,500
North Central Prairies	2,093,900	1,101,300
Edwards Plateau	7,642,200	1,565,400
Central Basin	654,200	134,500
Northern Rio Grande Plain	1,988,000	813,200
Western Rio Grande Plain	2,238,000	981,100
Central Rio Grande Plain	1,870,100	1,064,100
Lower Rio Grande Valley	240,300	55,800
West Cross Timbers	321,400	413,300
East Cross Timbers	38,300	74,900
Grand Prairie	1,002,600	463,300
Blackland Prairie	728,500	488,500
Claypan Area	1,034,300	792,000
East Texas Timberlands	6,500	4,800
Coast Prairie	740,500	78,000
Coast Saline Prairies	193,800	14,800
Flatwoods	-0-	-0-
TOTAL	31,320,600	10,182,800

undesirable woody species.

5.2 Water Demand Versus Supply

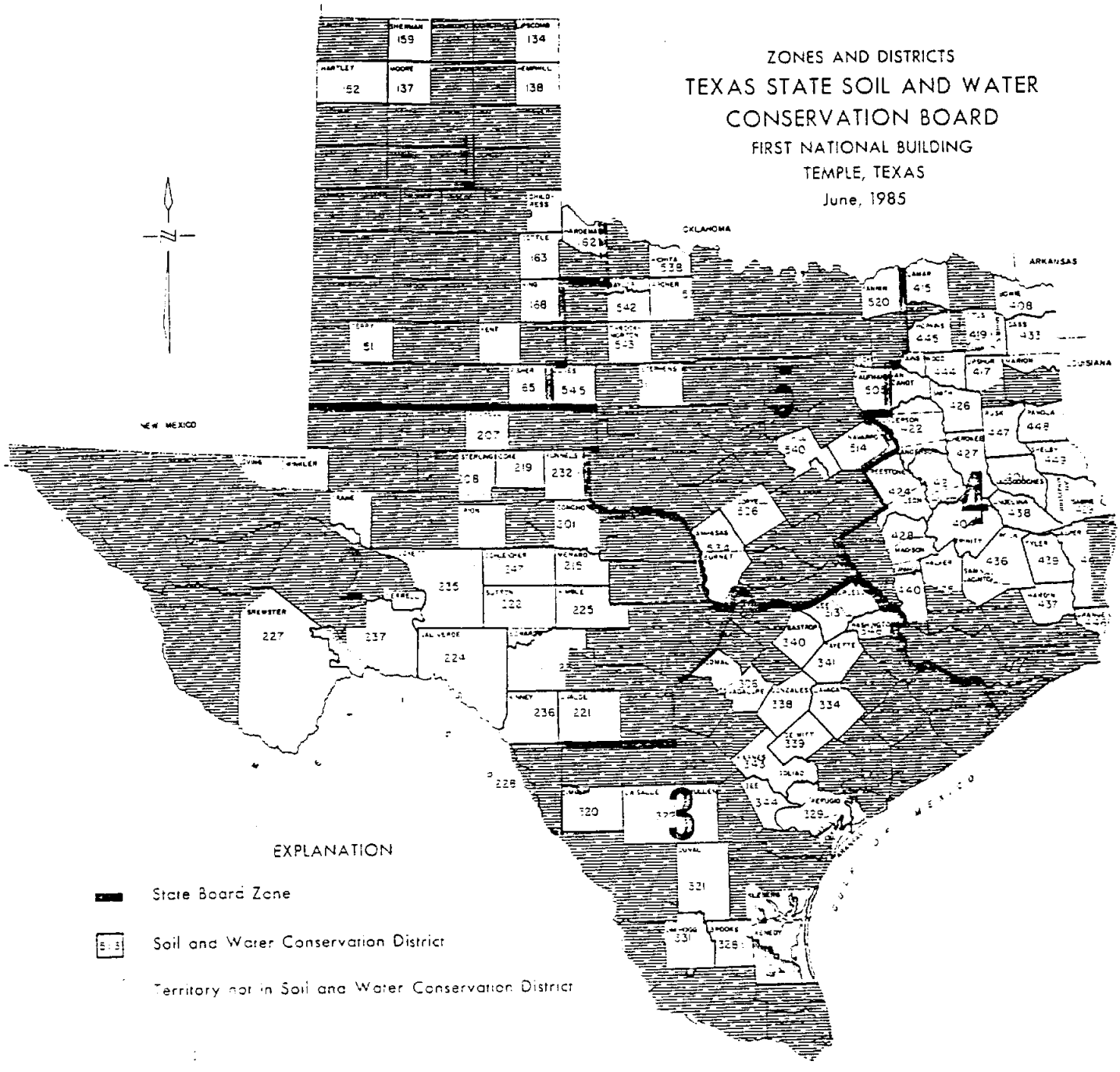
Many towns and cities in Texas are now or will in the future suffer water shortages. Since the major purpose of the brush control program is to provide additional yield from the rangeland watersheds of the state, a major consideration in delineating areas or prioritizing projects is the benefit to the people downstream. After determining who needs the water the most, then it is desirable to orient the critical areas so as to help the people most in need. There are many areas in the state of Texas where this is possible.

The following information was prepared by the Texas Water Development Board at the request of the State Board. Table 1 is a list of counties that have been estimated to have water supply problems by the year 2000. The list was compiled assuming no additional water supply projects are built and the growth in water requirements will reflect the estimated "High Case" growth projections as published in Water for Texas: Planning for the Future.

The list is in alphabetical order and classifies the problem as either municipal/manufacturing, irrigation, other, or a combination of two or more. No attempt was made to evaluate the infrastructure of the municipal, industrial or irrigation systems; thus, there could be additional areas with delivery or treatment capacity problems that are not on the list. The "other" classification indicates such problems as water quality, need for conservation, declining water tables, subsidence, or similar problems.

While the list of counties has not been prioritized, the Texas Water Development Board will assist the Texas Soil and Water

Counties With Projected
Water Supply Shortages
By The Year 2000



COUNTIES WITH WATER SUPPLY PROBLEMS BY 2000 (HIGH CASE)

COUNTY	TYPE OF PROBLEM: MUNICIPAL / MANUFACTURING	IRRIGATION	OTHER
Andrews		X	
Armstrong		X	
Atascosa		X	
Austin		X	
Bailey		X	
Bandera	X	X	
Bell	X		X
Bexar	X		X
Blanco	X		
Borden		X	
Bosque	X		
Brazoria	X	X	
Brazos			X
Briscoe		X	
Brown			X
Caldwell	X		
Calhoun			X
Callahan	X	X	
Cameron	X	X	
Carson		X	
Castro		X	
Chambers			X
Clay		X	X
Cochran		X	
Coleman			X
Collingsworth			X
Collins	X		
Colorado			X
Comanche		X	
Cooke			X
Crosby		X	
Culberson		X	
Dallam		X	
Dallas	X		X
Dawson		X	
Deaf Smith		X	
Delta			X
Denton	X		
Dickens		X	
Donley		X	
Eastland		X	
Ector			X
El Paso	X	X	
Ellis			X
Erath		X	
Falls	X		

COUNTIES WITH WATER SUPPLY PROBLEMS BY 2000 (HIGH CASE)

COUNTY	TYPE OF PROBLEM: MUNICIPAL / MANUFACTURING	IRRIGATION	OTHER
Floyd		X	
Foard		X	
Fort Bend	X	X	
Franklin			X
Frio		X	
Gaines			X
Galveston	X		X
Garza		X	
Gillespie	X		X
Glasscock		X	
Gray		X	
Grayson		X	
Gregg	X		
Hale		X	
Hall		X	
Hamilton	X	X	X
Hansford			X
Harris	X		X
Harrison	X		
Haskell		X	
Hays	X	X	X
Hidalgo	X	X	
Hockley		X	
Hood	X	X	
Howard		X	
Hudspeth		X	
Hunt			X
Hutchinson			X
Jack	X		X
Jackson		X	
Jeff Davis			X
Jefferson			X
Jim Wells		X	
Johnson			X
Kendall	X	X	
Kerr	X		X
Knox		X	
Lamb		X	
Liberty			X
Limestone			X
Live Oak	X	X	X
Llano	X		X
Lubbock	X	X	
Lynn		X	
Martin		X	
Mason	X		X

COUNTIES WITH WATER SUPPLY PROBLEMS BY 2000 (HIGH CASE)

COUNTY	TYPE OF PROBLEM: MUNICIPAL / MANUFACTURING	IRRIGATION	OTHER
Matagorda		X	
Maverick	X	X	
McCulloch	X		X
McLennan	X		X
Medina		X	X
Midland	X	X	
Milam	X		X
Mills	X		
Montague		X	X
Montgomery	X		
Motley		X	
Newton		X	
Nolan	X	X	
Nueces		X	X
Ochiltree			X
Oldham		X	
Palo Pinto	X	X	
Parker	X	X	
Parmer		X	
Pecos		X	
Potter		X	
Presidio		X	
Randall	X	X	
Reagan		X	
Real		X	
Red River		X	X
Reeves		X	
Roberts			X
Robertson		X	
San Patricio		X	X
San Saba	X	X	X
Scurry	X	X	
Shackelford		X	
Somervell	X	X	X
Starr	X	X	
Stonewall	X		
Swisher		X	
Tarrant	X		
Taylor	X	X	
Tom Green	X		X
Travis	X		X
Upton		X	
Victoria		X	
Waller		X	
Ward		X	
Webb	X	X	

COUNTIES WITH WATER SUPPLY PROBLEMS BY 2000 (HIGH CASE)

COUNTY	TYPE OF PROBLEM: MUNICIPAL / MANUFACTURING	IRRIGATION	OTHER
Wharton		X	
Wheeler		X	
Wilbarger		X	X
Willacy	X	X	X
Williamson	X		
Wilson		X	
Wise			X
Yoakum		X	
Young		X	
Zapata	X		
Zavala		X	

Conservation Board (TSSWCB) in developing a priority list.

Table 2 is a list of water supply reservoirs where brush control could possibly enhance water supplies. The following criteria was used in selecting the areas:

1. Where surface reservoirs have vacant storage and can accept an increase in surface flow.

2. Watershed of approximately 500 square miles or less and boundary conditions are minimized.

3. A record of historical baseflow.

4. Where brush clearance would progress upstream from a reservoir site.

5. Where zero or minimal stream diversions occur.

6. Where annual runoff averages more than 0.5 inches per square mile and less than 5.0 inches per square mile.

7. Where rainfall is between 15 and 36 inches per year.

8. Where trees can remain along streams and channelization is not necessary.

9. Where state and federal regulations to regarding wetland and pollution will not be violated.

10. Where brush and/or phreatophyte infestation exceeds 20 percent.

11. Where dissolution of near-surface salts is minimal and such areas can be identified.

12. Where municipalities have water supply problems.

13. Where the best historical data as available such as, stream flow and ground-water level.

14. Where ground-water recharge and storage can be increased.

Table 2. Surface Water Brush Control Areas

County	Reservoir	Water Course	User	Comments
Archer	Lake KIckapoo	N. FORK LITTLE WICHITA	Wichita Falls	
Archer	Lake Arrowhead	LITTLE WICHITA RIVER	Wichita Falls	
Bandera	Lake Medina	MEDINA RIVER	Medina Irr. Co.	
Baylor	Millers creek	MILLERS CREEK	N. Central Texas MWA	not more than 20% canopy
Blanco	Blanco river	BLANCO RIVER	Blanco	
Blanco	Johnson city lake	PEDERNALES RIVER	Johnson city	lake part of Pedernales river
Bosque	Bosque River	BOSQUE RIVER	Meridian	
Bosque	Bosque River	BOSQUE RIVER	Clifton	Perposed reservoir
Brown	Lake Brownwood	PECAN BAYOU	Brownwood WCID	Irr. and mun. supply
Burnet	Lake Georgetown	N FORK SAN GARBIEL	Brazos RA	
Callahan	Lake Baird	MEXIA CREEK	Baird	
Callahan	Lake Clyde	N PRONG PECAN BAYOU	Clyde	
Clay	Arrowhead	LITTLE WICHITA	Wichita Falls	
Coleman	Lake Coleman	JIM NED CREEK	Coleman	
Eastland	Lake Cisco	SANDY CREEK	Cisco	
Erath	Baileys Lake	KICKAPOO CREEK	Lipan	
Erath	Thurber lake	GIBSON CREEK	Thurber	
Falls	Lake Marlin	BIG SANDY CREEK	Marlin	
Falls	Lake Rosebud		Rosebud	
Goliad	Coleto Creek	COLETO CREEK	Guadulupe-Blanco R.A	Power cooling lake
Hamilton	Leon River	LEON RIVER	Hamilton	Above Proctor
Haskell	Lake Stanford	PAINT CREEK		
Jack	Lake Jacksboro	LOST CREEK	Jacksboro	
Jim Wells	Lake Alice	CHILTIPIN CREEK	Alice	
Johnson	Lake Cleburn	NOLAN RIVER	Cleburn	
Jones	FT Phantom Hill	ELM CREEK	Abilene	
Kimble	Lake Junction	LLANO RIVER	Junction	
Kindall	City lake	CIBOLO CREEK	Boerne	
LLano	LLano City lake	LLANO RIVER	LLano	
Mills	City lake	COLORADO RIVER	Goldthwaite	
Mitchell	Lake Colorado City	MORGAN CREEK	Colorado City	
Montague	Lake Noconia	FARMERS CREEK	Noconia	
Montague	Amon Carter	SANDY CREEK	Bowie	
Nolan	Lake Trammel	SWEETWATER CREEK	Sweetwater	
Nolan	Lake Sweetwater	BITTER CREEK	Sweetwater	
Palo Pinto	Palo Pinto	PALO PINTO CREEK	Palo Pinto MWD	
Palo Pinto	Lake Mingus	GIBSON CREEK	Mingus	
Palo Pinto	Tucker Lake	RUSSELL CREEK	Strawn	
Parker	Lake Weatherford	CLEAR FORK TRINITY	Weatherford	
Real	Camp wood Creek	CAMP WOOD CREEK	Camp Wood	
Runnels	Lake Winters	ELM CREEK	Winters	
Runnels	Lake Ballinger	VALLEY CREEK	Ballinger	
Shackelford	McCarty lake	SALT PRONG HUBBARD CREEK	Albany	
Somerville	Paluxy River	PALUXY RIVER		Base flow decline
Stephens	Lake Daniel	GONZALES CREEK	Breckenridge	
Stephens	Hubbard Creek	HUBBARD CREEK	W Central Texas MWD	
Taylor	Lake Abilene	ELM CREEK	Abilene	
Taylor	Lake Kirby	CEDAR CREEK	Abilene	

Table 1. Surface Water Brush Control Areas

County	Reservoir	Water Course	User	Comments
Taylor	Lake Lylte	LYLTE CREEK	Abilene	
Uvalde	Leona River	LEONA RIVER		Increase base flow
Val Verde	San Felipe	SAN FELIPE CREEK	Del Rio	San Felipe springs
Victoria	Coleto Creek	COLETO CREEK	GBRA	Cooling res
Williamson	Lake Georgtowm	N FORK SAN GARBIEL	Brazos RA	
Young	Lake Olney		Olney	
Young	Lake Graham	SALT CREEK	Graham	
Young	Lake Whiskey Creek	WHISKEY CREEK	Newcastle	
Zavala	Upper Nueces	NUECES RIVER		Irr.

15. Where hydrogeological conditions are favorable.

16. Where the ratio of water use by brush/phreatophytes covered areas converted to grasslands or other vegetation is favorable. Also, where the ratio of the soil moisture with and without the brush is favorable to induce ground-water recharge.

17. Most areas considered under the preliminary criteria outlined above can expect an increase in surface-water run off. With respect to ground-water augmentation, however, the hydrogeological setting plays an important role in the selection. For example, streams should traverse the recharge outcrops of aquifers; and if faulting exists, this would be even better. Along the breaks of the Edwards Plateau, brush control would perhaps result in increased spring flows.

5.3 Potential Water Yield

Expertise probably exists to make fairly accurate predictions as to rangeland areas where potential is high for increasing water yields. Very little work has ever been done to apply the hydrological and geological information available to this field. The development of reliable indicators for predicting potential yields should be a high priority of the brush control program. As mentioned in an earlier section, the Texas Water Development Board has offered their help and there is little doubt that there are other agencies and groups who would be willing to lend assistance. Several of the goals incorporated into current research efforts by the Texas Agricultural Experiment Station will be helpful in predicting yield potential.

5.3a Geological Information

An essential ingredient in successfully increasing the water

yield from an area for downstream or aquifer use is water transfer. The precipitation that falls on the land and is absorbed must have an avenue to underground aquifers before it can recharge them and/or emerge as spring flow. Land where this hydrologic transfer is possible should be considered as high potential areas for the purposes of this program.

5.3b Climatic Conditions

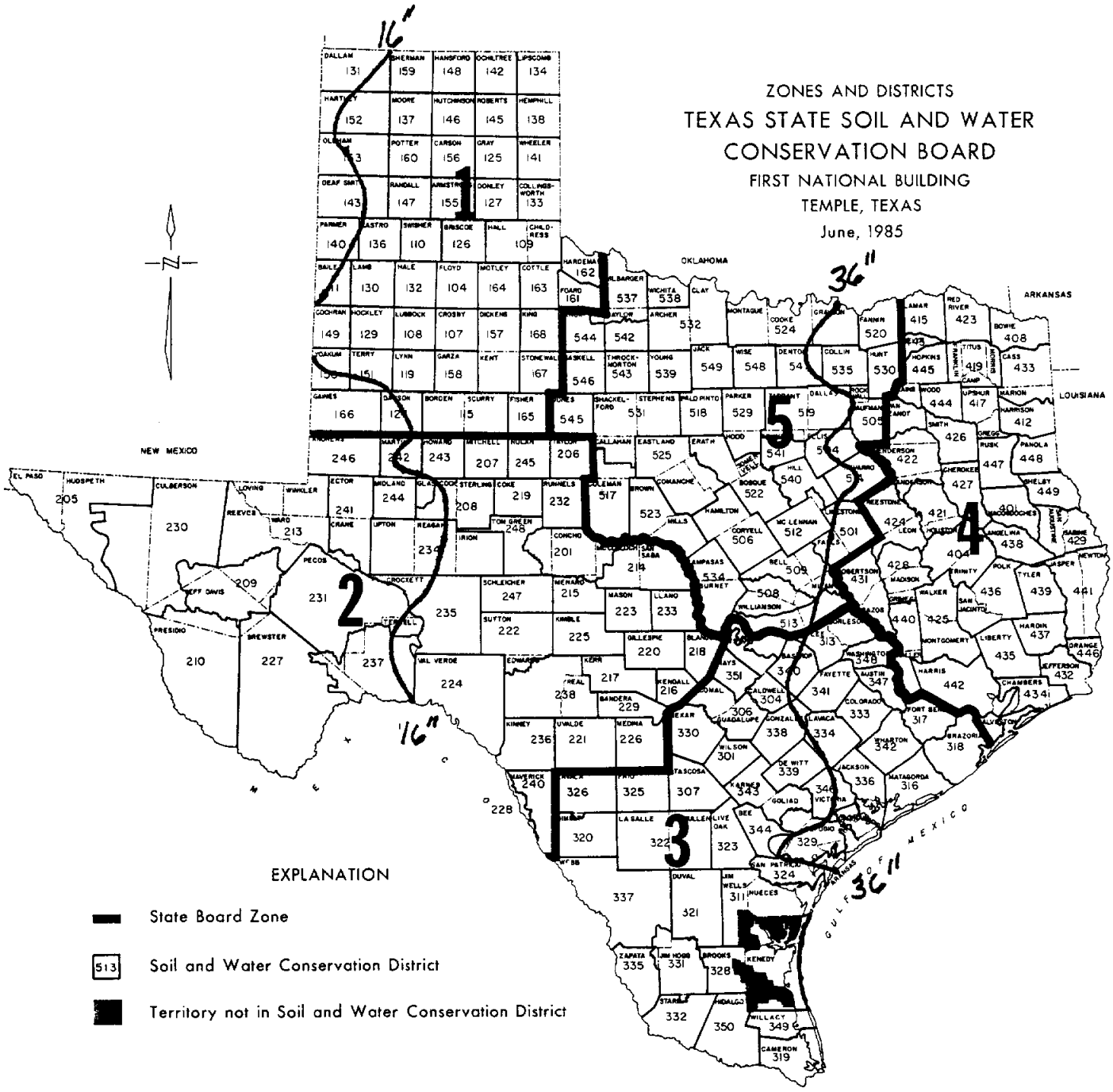
The amount of precipitation that falls on the land is directly related to the water yield potential. Therefore, practical limits must be set as to how much average annual rainfall is necessary to allow potential enhancement. There is a point where even grassland will use all of the available moisture. The weighing of water needs in the area with yield potential may justify projects with lower potential while less need for water may negate larger yield potentials.

5.3c Historic Evidence

Until research is completed and data and expertise are gathered on other methods of determining yield potential, historic evidence is probably the most reliable indicator of water enhancement possibilities. In many areas of the state, historical records indicate much higher levels of spring flow and base flow of rivers and streams than is now apparent. Brush encroachment along with other factors caused declines in these base flows. After investigating irrigation records and municipal and industrial use in the area, portions of the state with large amounts of positive historical evidence would be some of the most likely candidates for critical area delineation.

Critical Area Deliniation

Until sufficient progress is made in the actual determination of potential yield the deliniation of critical areas statewide will be based on the location of infestations of mesquite, blue-berry and red-berry junipers, South Texas brush complex, and salt cedar. Areas in Texas with infestations of these species located between the 16 inch rainfall belt and the 36 inch rainfall belt will be eligible for the program. (See map) Proposed projects located outside of this area will be reviewed on a case-by-case basis.


ZONES AND DISTRICTS
TEXAS STATE SOIL AND WATER CONSERVATION BOARD
FIRST NATIONAL BUILDING
TEMPLE, TEXAS
June, 1985
OKLAHOMA
ARKANSAS
LOUISIANA
NEW MEXICO
GULF OF MEXICO
1
2
3
4
5
EXPLANATION
State Board Zone
Soil and Water Conservation District
Territory not in Soil and Water Conservation District

Section VI. Project Applications

6.1 Sponsorship - Soil and Water Conservation Districts

Local soil and water conservation districts will be the key to the development of workable project applications and successful brush control projects. Many districts have had experience in the past in the development and implementation of P.L. 566 Watershed Projects as well as other types of locally initiated projects. When local interst is such that action is deemed necessary, someone must lead and coordinate the effort. Soil and water conservation districts are qualified to assume this role. They are accessable to anyone and they especially have considerable experience in working with landowners and landusers, both individually and as a group.

The following is a copy of those sections of S. B. 1083 - "Subchapter D. Powers and Duties of Districts" that pertain to the initiation and application phases of a brush control project.

Subchapter D. Powers and Duties of Districts

Section 203.101. General Authority. Each district may administer the aspects of the brush control program within any critical area located within the jurisdiction of that district.

Section 203.102. Provide Information Relating to Program. The board shall prepare and distribute information to each district relating generally to the brush control program and concerning the procedures for preparing, filing, and obtaining approval of an application for cost sharing under Subchapter E of this chapter.

Section 203.103. Acceptance and Comment on Application. (a) Each district may accept for transmission to the board applications for cost sharing under Subchapter E of this chapter and may examine and

assist the applicant in assembling the application in proper form before the application is submitted to the board.

(b) Before a district submits an application to the board, it shall examine the application to assure that it complies with rules of the board and that it includes all information and exhibits necessary for the board to pass on the application.

(c) At the time that the district examines the applicatoin it shall prepare comments and recommendations relating to the application and the district board may provide comments and recommendations before they are submitted to the board.

(d) After reviewing the application, the district board shall submit to the board the application and the comments and recommendations.

6.2 Requirements of the Application

1. An application must denote sufficient interest by a group of landowners and operators in a critical area or a subpart of a critical area designated by the State Soil and Water Conservation Board to allow for the eventual completion of the project.

2. A valid application must show adequate sponsorship by one or more soil and water conservation districts. Enlisting additional sponsors such as cities, counties, other political subdivisions, etc. could be beneficial to the project and should be encouraged.

3. The soil and water conservation districts involved must agree to take leadership and coordinate the project through implementation.

4. The project area proposed in the application should be of sufficient size to provide a significant potential gain in the water

yield from the critical area where the project is located.

5. The application should provide as much evidence as possible that the acreage to be treated within the project area does have the potential to improve water yields. Subjects that should be addressed are:

a. size and location of the area

b. brush - type and density

c. water needs or potential needs

d. potential yield

e. wildlife compatability to the project

f. landowner cooperation

g. ability of participants to pay their share of the cost

h. types of treatment measures

i. completion schedule

6. Applications should be submitted on forms provided by the State Board to the Texas State Soil and Water Conservation Board, P.O. Box 658, Temple, Texas 76503.

The State Board will of course stand ready to assist districts in the development of project applications.

Section VII. State Board Approval and Prioritization

7.1 Preliminary Field Examination

The State Board will most likely be involved with all project applications during the preapplication phase. Considerable information will have to be gathered to meet the requirements of the project application. The final document should give a fairly accurate assessment of the potential for that particular project. Once the application is complete and has been received by the State Board it will be necessary for State Board staff together with a team of experts in related fields to perform a preliminary field examination of the area.

This examination has two basic puposes:

1. To determine if the infomation in the application is complete and sufficient to meet requirements for approval by the State Board.

2. To make a determination of the relative merit of the project for use by the State Board in granting priorities.

After determination has been made that the application meets requirements for it to be approved by the State Board, then each of the project prioritization criteria as set up in the state plan will be applied to the project application. The project area will be ranked in each category and this ranking will be recorded in the field examination for use by the State Board. Any other information relating to the viability of the project or relating to the prioritization of the project will be recorded.

7.2 Application Approval

An application received by the State Board will be approved or

disapproved after a preliminary field examination is held in the project area. Two requirements must be met before approval is granted.

1. The application must include in as much detail as possible all of the information described in Section 6.2. This information must show that in the best judgement of those preparing the application the project area will meet minimum requirements to be feasible.

2. The preliminary field examination must show that the application is indeed complete and accurate and meets minimum requirements in all six project prioritization criteria.

Should the application meet requirements set forth by the State Board it will be approved. This approval signifies that the project is viable and should be considered in the prioritization process.

Project applications that are disapproved may be reconsidered after evidence is presented that would make them feasible.

7.3 Prioritization of the Project for Planning

At this date, there is no way to foresee how many project applications will be received by the State Soil and Water Conservation Board. The amount of cost share funding provided by the state as well as the general economic condition of farming and ranching will undoubtably play a large part in determining this. Provision must be made, however, to select the projects that will be most effective in reaching the goals of the program.

Section 203.159 of the law states that (a) If the demand for funds under the cost sharing program is greater than funds available, the board may establish priorities favoring the areas with the most critical water conservation needs and projects that will be most likely

to produce substantial water conservation.

The project prioritization criteria discussed in Section VIII were developed to give the State Board an impartial way to evaluate each project application. A project application that is ranked high in the various categories will receive a planning priority ahead of projects with problems in some areas. This will also allow the Board to objectively view new applications in relation to applications that have been on the books for some time. By the fact that the ranking process points out deficiencies in the application, projects with a low planning priority may be upgraded through improvements in those areas in which they are weak.

Section VIII. Project Prioritization Criteria

8.1 Brush - Type and Density

A list of brush species in the state will be developed and made a part of the brush control plan ranking each species according to its water use potential. This ranking will also include information on the minimum density for each species to make control cost effective. The first list of brush type and density will be the best estimates of knowledgeable range scientists. As more research becomes available the list will be revised as needed.

The brush species list will be used during the preliminary field examination to establish that the brush infestation in the proposed area meets minimum requirements for a brush control project. After this is established, the type and density of the brush will be ranked as to severity and this will be a factor in the overall ranking of the project.

8.2 Water Needs or Potential Needs

This information will be obtained on a project-by-project basis from the Texas Water Development Board. They have agreed to provide technical support in the following areas:

1. surface-water engineering
2. ground-water hydrogeology
3. agricultural engineering
4. economic analysis
5. systems engineering in computer analysis, programming, etc.
6. soils analysis
7. core drilling and monitor well installation with

instrumentation

8. weather station installation
9. data collection
10. historical baseflow data
11. baseflow computations
12. historical water level data from wells
13. modeling of water levels
14. locate recharge areas
15. locate areas where small reservoirs can be augmented by increase flow
16. show municipalities with water problems
17. work with cities to set up water conservation programs
18. work with area farmers and ranchers to maximize water yields
19. check permits
20. inventory pumpage
21. work with area farmers on conservation programs

8.3 Potential Yield

As pointed out in earlier sections, technical information on this subject is very scarce. Until research can provide a scientific methodology for assessing the potential for increasing water yields in a given area, we will be forced to use a less exact method. With the use of available information, however, it is possible to make a determination as to potential yield. There are three basic areas which would most likely provide clues as to potential yield.

(1) Historic Evidence - As Barney Jefferson, longtime SCS district conservationist and fieldman for the State Board once said,

" You can't make water where none existed in the first place." This is a true statement especially when applied to a brush control project for increasing water yields. Due to the fact that very little brush existed on the rangelands of the state when the first settlers arrived, historical records can many times be used to document early spring flow, stream flows, or high underground water tables. Areas with large amounts of positive historical evidence would receive a higher potential yield ranking on the premise that the heavy brush infestation is at least partially responsible for the decline in the water yield of the area.

This assumption would be further verified by checking irrigation records and municipal and industrial use in the area.

(2) Climate Conditions - Obviously the precipitation that falls on a given area has quite a lot to do with the potential water yield of that area. With all other factors being equal the area that has a higher average rainfall should have more water yield potential. This is not to say that the drier areas of the state will not receive consideration since many other factors such as need, geological potential, and brush infestation are also factors. Temporary drought conditions or abnormal wet periods must also be considered in trying to determine the effect of climate on potential yield.

(3) Geological Information - Probably the most inportant ingredient in successfully increasing water yields in an area for downstream use is water transfer. Precipitation that falls on the land must have an avenue to underground aquifers before it can recharge them and/or emerge as beneficial spring flow. While considerable hydrological and geological experience exists in this area, little effort has been made in the past to apply the principles involved to

the rangelands of the state. One of the long term goals of the state brush control program should be to encourage efforts in this field. In the meantime, sufficient knowledge and experience does exist to be most helpful in making potential yield determinations on a project-by-project basis. Experts in geology and hydrology will be a part of the preliminary field examination team.

8.4 Wildlife Considerations

Section 203.106 of the law states that "The board shall consult the Parks and Wildlife Department in regard to the effects of the brush control program on fish and wildlife."

From the beginning of SB 1083, incorporating fish and wildlife concerns into the planning and implementation of brush control and revegetation projects has had a high priority. If properly included in brush control planning, maintenance and even enhancement of wildlife habitats is possible.

The Texas Parks and Wildlife Department is presently involved with the State Board in coordinating the fish and wildlife aspects of the program. They are developing criteria to be used in commenting on project applications. Parks and Wildlife personnel will be included in the preliminary field examination team and will help determine the feasibility of project applications. They will be asked to provide a ranking of project applications for use by the State Board. This ranking would include a prioritized listing of the wildlife species in the area with the effect that the proposed brush control project would have on them.

8.5 Landowner Cooperation

Cooperation of the landowners and operators in the project area

Section IX. Project Planning

9.1 Practice Selection

Section 203.055 of the law states: (a) The board shall study and must approve all methods used to control brush under this Act considering the overall impact the project will have within critical areas.

(b) The board may approve a method for use under the cost-sharing program provided by Subchapter E of this chapter if the board finds that the proposed method:

(1) has proven to be an effective and efficient method for controlling brush;

(2) is cost efficient;

(3) will have a beneficial impact on the wildlife habitat;

(4) will maintain topsoil to prevent erosion or silting of any river or stream; and

(5) will allow the revegetation of the area after the brush is removed with plants that are beneficial to livestock and wildlife.

In practice the State Board will consult with the Soil Conservation Service and others to determine the types of practices that are normally used in the project area for brush control and revegetation. A list of approved practices will then be furnished to the district for review and comment. This list will then be used in developing individual plans.

Identifiable units must be established for each practice. An indentifiable unit must be either all or an essential part or subdivision of a practice that when carried out is complete within itself and can be clearly identified. Establishment of identifiable

units and an average cost of a specified maximum cost permits cost-share payments to be made to producers when an identifiable unit is carried out. A list of practices, applicable cost-share rates, average costs or specified maximum costs will be developed for each.

9.2 Site Eligibility Studies

Before individual landowner plans can be developed, decisions will have to be made in each project area concerning the practices which will be eligible for cost sharing on certain general categories of land. First an evaluation will be performed to group similar combinations of topography, soils, land use, or grazing systems into categories. Then each category of land will be assigned a set of practices that will be eligible for cost sharing. These categories should be broad enough to allow some flexibility on the part of the landowner but still prevent extravagant project costs. Generally certain land classes with a certain brush canopy would be eligible for a given set of practices. Some practices may be excluded in some areas for reasons such as infeasibility, wildlife considerations, or local, state, or federal regulation.

9.3 Wildlife Considerations - Planning for Wildlife Objectives

The basic concern of the wildlife manager in implementing any brush management system has to do with the design and retention of a brush mosaic. Patterning of brush treatments is driven by wildlife considerations more than by any other set of management objectives. The design of a favorable habitat mosaic is strongly influenced by (1) range site, (2) kinds and pattern of brush present to be controlled, (3) efficacy of different brush management techniques for controlling this brush, (4) the ability to establish desired patterns with

effective treatments, (5) imagination in development of patterns, and use of brush management techniques to accomplish them, (6) economic response projected for different possible brush management systems, and finally, (7) preferences of ranch operators among economically feasible designs.

When a certain segment of a ranch is to be subjected to range improvement, the first step of wildlife interpretation should be to characterize the importance of that segment as part of the wildlife habitat on the ranch as a whole. Size of area treated, proportion of the ranch area, and the importance of this area's contribution to ranch game habitat before treatment all affect wildlife management strategy. As much as possible treatments should emerge from planning efforts that contribute to regional habitat conditions. For example, brush areas along the margins of, or in insular blocks in, large brush-free areas, have the effect of incorporating parts of the brush-free areas into a regional habitat mosaic. The brush areas make up the "core" of a regional habitat. Brush treatment strategy at such sites must be much more conservative than a strategy associated with a less marginal site.

On the other hand, if the treated area is embedded in a large region of mature thicketized brush, treatment strategy could be much more aggressive. Treatment patterns should be used to create a habitat mosaic that retains, in as much as possible, valuable features of the original game habitat. Design of the mosaic should create patterns that allow the treated segment to carry its own populations of game, to contribute to diversity of the habitat in the surroundings, and to favor hunting.

Laying out a proposed habitat mosaic begins with the identification of features of the pretreatment stand of brush that have

special utility, prime loafing-bedding grounds for deer, for example. These should act as focal points in the pattern of brush retained as a post-treatment brush mosaic. The lay of the land (terrain, pattern of range sites, brush types, shape of treated pasture, treatment history, etc.) affects the pattern that the residual brush mosaic can take, so each design effort is somewhat unique. Several possible treatment patterns should emerge from this analysis by the wildlife specialist.

Simultaneously a series of feasible alternative techniques for treating the brush should emerge as a result of analysis by brush and range managers. These two aspects of planning converge to produce a set of feasible pattern/treatment combinations for consideration as alternative treatments.

Feasibility is finally a function of the compatability of patterns and treatments in time. For example, a pattern of strips cleared on the contour or in a zig-zag pattern could be installed by some mechanical methods but probably not sprayed on from fixed-wing aircraft. Rectilinear strips could be done either way. A variable-rate pattern could only be applied from an aircraft. Incorporation of prescribed burning in a system will demand deferrals which may not be feasible in the time alloted.

It is likely that only a few candidate pattern/treatment combinations will emerge for which equipment is locally available and which suits the preferences of ranch management. These should be ranked by wildlife specialists in terms of their utility for satisfying game management objectives from a biological point of view. Interaction and compromise among management objectives should result in further limitation of alternatives and finally result in identification of the candidate system that shows most promise for meeting the goals

of the program.

9.4 Cost Share Rate

Average costs and specified maximum costs must be developed annually for each project and must be approved by the State Board after consultation with the sponsoring districts. Average costs and specified maximum costs will be developed for a twelve-month period. Average costs and specified maximum costs cannot be effective before the date they are approved by both the State Board and the sponsoring districts.

Necessary changes in average costs and specified maximum costs may be approved at any time. Generally, changes should not be made in average costs unless actual costs have increased or decreased by 10% or more. If only a few changes in average costs are required, it is not necessary to prepare a complete new list each year. Changes may be accomplished by a supplement which must be reviewed and approved in the same manner as a complete list.

Determination of average costs - The basic element in the determination of an average cost is the actual cost to producers. Data on actual costs must be collected on a continuing basis from producers. Actual cost data must be collected on a representative number of jobs on all eligible practices in a project area. Such data need not be collected on all jobs. In the determination of average costs, information from suppliers, ASCS, land grant colleges, and other sources may be considered in addition to data collected from producers. All cost data used in determining average cost must be on file in the State Board offices.

Cost share rates - The State Board will set cost share rates for

1985 GPCP Average Costs for Brush Control

Wilbarger

	Mechanical (30%)	
Heavy	- Rootplow/treedoze	$ 45.00/acre
	- Stacking/piling	25.00/acre
	- Seedbed preparation	11.50/acre
	- Seed (range mix)	21.00/acre
	- Seeding operation	4.00/acre
	- Total	$106.50/acre
	Chaining (two way)	$10.00/acre
	Chemical (70%)	
	Liquids (Grazon ET etc.)	$ 10.00/acre
	Pellets (Grassland, etc.)	34.00/acre

If 100,000 acres of brush control and reseeding where necessary were applied in this county using 1985 GPCP average costs and actual application percentages for each practice, the following figures can be derived:

28.5%	Treedoze/rootplow	28,500 ac. x $106.50/ac. =	$3,035,250
1.5%	Chaining (2 way)	1,500 ac. x $ 10.00/ac. =	15,000
70.0%	Chemical (liquid)	70,000 ac. x $ 10.00/ac. =	700,000
100 %		Total cost	$3,750,250
		70% Cost share	$2,625,175

1985 GPCP Average Costs for Brush Control

Edwards-Real

	Mechanical (95%)	
Heavy	- Rootplow/treedoze	$30.00/acre
	- Raking/stacking	23.00/acre
	- Seedbed preparation	8.50/acre
	- Seed (range mix)	21.00/acre
	- Seeding operation	5.00/acre
	- Total	$87.50/acre
	Hand cutting cedar	$23.00/acre
	Chemical (5%)	
	Liquids	$ 7.00/acre
	Pellets	25.00/acre

If 100,000 acres of brush control and reseeding where necessary were applied in these counties using 1985 GPCP average costs and actual application percentages for each practice, the following figures can be derived:

47.5%	Treedoze/rootplow	47,500 ac. x $87.50/ac. =	$4,156,250
47.5%	Hand cut cedar	47,500 ac. x $23.00/ac. =	1,092,500
5.0%	Chemical (liquid)	5,000 ac. x $ 7.00/ac. =	35,000
100 %		Total cost	$5,283,750
		70% Cost share	$3,698,625

1985 GPCP Average Costs for Brush Control

Webb County

Mechanical (95%)

Heavy	- Root plowing	$35.00/acre
	- Stacking/piling	25.00/acre
	- Seedbed preparation	8.00/acre
	- Seed (range mix)	21.00/acre
	- Seeding operation	5.00/acre
	- Total	$94.00/acre

Chemical (5%)

Liquids	$15.00/acre
Pellets	34.00/acre

If 100,000 acres of brush control and reseeding where necessary were applied in this county using 1985 GPCP average costs and actual application percentages for each practice, the following figures can be derived:

95%	Root plow	95,000 ac. x $94.00/ac. =	$8,930,000
5%	Chemical	5,000 ac. x $15.00/ac. =	75,000
100%		Total cost	$9,005,000
		70% Cost share	$6,303,500

1985 GPCP Average Costs for Brush Control

Tom Green

Mechanical (20%)

Heavy	- Rootplow/treedoze	$36.00/acre
	- Raking/stacking	18.00/acre
	- Seedbed preparation	9.00/acre
	- Seed (range mix)	21.00/acre
	- Seeding operation	3.50/acre
	- Total	$87.50/acre
	Chaining (two way)	$10.00/acre

Chemical (80%)

Liquids (Grazon ET, 245T, etc.)	$15.00/acre
Pellets (Grassland, etc.)	30.00/acre

If 100,000 acres of brush control and reseeding where necessary were applied in this county using 1985 GPCP average costs and actual application percentages for each practice, the following figures can be derived:

6%	Rootplow/treedoze	6,000 ac. x $87.50/ac. =	$ 525,000
14%	Chaining (2 way)	14,000 ac. x $10.00/ac. =	140,000
80%	Chemical (liquid)	80,000 ac. x $15.00/ac. =	1,200,000
100%		Total cost	$1,865,000
		70% Cost share	$1,305,500

all practices selected for use in a project area. The law places a 70% maximum on all cost sharing under the program. Rates should be reviewed annually by the State Board and sponsoring districts.

9.5 Completion Schedule

Proper timing and sequence of land treatment are essential to successful implementation of any conservation program. This is true concerning either the entire project or individual landowner plans. One major factor that enters into a state cost share program is the time limits placed on the use of state money. State funds are appropriated on an annual basis. This will allow only one year contracts even though the entire project may take several years to complete. Therefore, during the planning process schedules must be devised that will allow the orderly completion of the long-term project using annual appropriations and one year contracts. The completion schedule will provide a sequence for carrying out the planned measures.

9.6 Individual Landowner Plans

The responsibility for sound planning and effective agreement with cooperators rests with the district involved. Each district must exercise good judgment and integrity in determining program eligibility for each case and in assuring that the cooperator fully understands and agrees with sound provisions for installation and maintenance of needed measures. Districts will be sure that consideration is given to all sound treatment alternatives. Program cost share will be limited to that required for the most cost effective treatment that is technically sound for the eligible areas. Any treatment planned beyond that will be installed with funds other than brush control funds. In summary, an adequate plan must: (a) provide cost share only on eligible areas,

(b) provide cost share only for the most cost effective treatment. "Cost effective" means the least costly treatment that will accomplish the desired goal.

The plan will show:

(1) Planned treatment for the land the producer has in the program. The practices to be applied shall be identified and each identifiable unit shall be listed.

(2) Estimated extent or amount of each identifiable unit.

(3) Average cost, or specified maximum cost, current at the time the plan is developed for each identifiable unit.

(4) Cost-share rate for each identifiable unit.

(5) Time schedule, by year, for carrying out each identifiable unit.

(6) Estimated total state cost share, by year, for each identifiable unit.

(7) Primary purpose for each cost-shared practice. Annual recurring-type practices are not eligible for cost sharing in this program. If these practices are considered essential conservation treatment, they must be planned and carried out. These may include practices such as proper grazing.

Section X. Cost-Share Program

10.1 State Board Role

Subchapter E., Section 203.151 of the law states that "As part of the brush control program, a cost-sharing program is created to be administered under this chapter and rules adopted by the board." Section 203.152 of the law creates the brush control fund which is a special fund in the state treasury to be used to provide the state's share of the cost of brush control projects. Sections 203.156, 203.157, and 203.158 discuss individual applications for cost share assistance and section 203.160 states that "on approval of an application by the board, the board or the governing board of the designated district shall negotiate contracts with the successful applicants in the project area." Section 203.161 provides for the administration of cost-share funds.

The above portions of the law summarize the basic elements necessary for a cost-share program. After the cost-share program has been initiated in a project area, the role of the State Board will basically be an administrative one. As applications are approved and contracts are signed by the board or a district delegated by the board, individual landowners will proceed with the work specified in their contract. As the work is completed or an identifiable unit of the plan is completed the district will certify this to the State Board. This certification along with a claim from the landowner will be processed by the State Board and payment will be made directly to the landowner.

In the initial stages of the program more of the planning and cost-sharing functions will be carried out by the State Board. As procedures are refined and the program progresses, hopefully districts

will be able to assume most of the responsibilities.

Cost sharing by the State Board: (a) cost sharing may be on the basis of (1) average cost, (2) actual cost not to exceed the average cost, or (3) actual cost not to exceed a specified maximum cost. The State Board will set the average cost in each project area annually.

It is the general policy of the State Board to cost share on the basis of average cost. However, there are instances when cost sharing on an actual cost basis will be the most equitable.

Examples of when cost sharing should be on an actual cost not to exceed the average cost basis are:

(1) When it appears that the quantity of materials, supplies and services to be procured by the producer will result in costs less than the established average cost because of a quantity discount.

(2) When it is possible there might be a downward change in cost of materials, supplies, and services to be procured by the producer that would result in a "windfall" to the producer.

An example of when cost sharing should be on an actual cost not to exceed a specified maximum cost basis is when there is not an established average cost and there isn't sufficient cost data available to determine an average cost.

Each identifiable unit to be cost shared on the basis of actual cost not to exceed the average cost, or actual cost not to exceed a specified maximum-cost must be clearly identified in the contract. When cost sharing is to be on an actual cost basis, the producer must be informed of what will be required to support his application for payment.

Contracts may be modified to change the method of cost sharing from average cost to actual cost and vice versa at any time prior to

the date the indentifiable unit is started.

Cost-share percentage rates established in the contract for the primary purpose of a practice must remain unchanged for the life of the contract unless the primary purpose changes.

The following will apply to cost sharing where conservation practices are destroyed or broken up:

If the practice destroyed or broken up is not replaced by needed measures, all cost share paid, cost of materials used, and services purchased under authorization for the practice shall be refunded.

10.2 Soil and Water Conservation District Role

In order for the program to be successful districts will have to play an active part. They will be involved as sponsors from the beginning of a project and will have to administer the program at the local level. Technical assistance to landowners and operators will be provided through the district. An active educational effort will be one of the most important functions of the district. The same principles used by districts for 40 years to put conservation on the ground will be equally important in this program.

As landowner applications are received, district boards will review them and set priorities for developing plans of operations. An agreement with the USDA-Soil Conservation Service will have to be worked up to provide technical assistance in developing farm plans. The State Board will also help in providing technical assistance funds to the district. As plans are developed on individual farms and ranches the district will review these plans and, subject to State Board approval, negotiate annual contracts with landowners to do that portion of the work described in the plan which can be accomplished

during the year.

When contracts are signed the district will have responsibility for certifying that the work is accomplished as specified in the plan. Certification of completion of identifiable units of the plan will be made by the district to the State Board.

The district will:

(1) receive applications and determine eligibility

(2) review applications to determine priorities

(3) provide technical assistance to producers in developing their plan of operations

(4) review all plans of operations

(5) develop and process the contract based on the plan of operations

(6) provide technical assistance to the producer in carrying out the plan of operations

(7) provide assistance to producers in developing contract modifications

(8) inform the State Board of all alleged or suspected violations

(9) develop and carry out an information program

(10) make an annual progress review and report of each current contract

(11) make final on-site review and report of all expiring contracts

10.3 Landowner Agreements

The individual farm plan will be the basis for all contracts. While the plan may cover several years, contracts will be written on an

annual basis. The brush control, revegetation, and management plan with the landowner or operator is the basic agreement. A part of this agreement is a schedule of completion based to a large extent on the capabilities and wishes of the landowner. Annual contracts will cover a certain portion of the work described in the plan. After the contract is signed, materials or services needed by the producer to carry out his contract will be obtained by the producer. Technical assistance will be provided in carrying out the items specified in the contract by the district. Upon completion of an identifiable unit of the contract and certification by the district, the landowner will submit a claim for payment to the State Board.

Producer eligibility: Any producer who has control of an operating unit in a designated county, is eligible for participation in the program provided that: (1) the producer submits an acceptable plan of operations and (2) has control of the operating unit for a period required to carry out the plan of operations.

Contracts: Contracts shall be based on the producer's plan of operations, and shall be developed by the State Board or a district designated by the Board and the producer.

The beginning date of a contract is the day it is signed by the producer. The contract is not binding on the part of the state until (1) the contract is signed by the State Board and (2) the State Board certifies that funds are available for the cost-share obligation of the contract.

A producer is on his own so far as cost sharing is concerned for an identifiable unit(s) started after he has signed the contract, but before the contract is signed by the State Board and before the State Board certifies that funds are available for the contract cost-sharing

obligation.

10.4 Certification and Payment

Cost-share payments shall be made at cost-share rates specified in the contract, at the average cost, or the actual cost not to exceed the average cost, or the actual cost not to exceed the specified maximum cost as set forth in the contract. Cost-share payments are made for carrying out identifiable units and are conditioned upon approval of the certificate of performance and compliance by the district. The district shall submit to the State Board the application for payment with the certificate of performance and compliance. The district may also utilize the assistance of private, state and other federal agencies in discharging the responsibility for certification of performance and compliance.

Manner and time of cost-share payments: Cost-share payments shall be paid to the producer after he has carried out an identifiable unit of his contract. Payments shall be made as soon as practicable after the identifiable unit is carried out and the extent of performance has been established. It shall be the responsibility of the producer eligible for cost-share payments to establish his claim to such payments. Cost-share payments for identifiable units carried out under the program will be made only upon application submitted to the State Board. Application for cost-share payments shall specify the proportions of each producer's contribution to the carrying out of each identifiable unit. Cost-share payments will be made only for the identifiable units carried out in the year of the contract.

The cost-share amounts shown in the plan of operations are estimates only. Payments will be made at cost-share rates specified in

the contract for the actual amount or extent determined after work is performed. Payments will be based on average costs, unless it is provided in the plan of operations that payment will be based on actual cost not to exceed the average cost or actual cost not to exceed a specified maximum cost.

Significant Changes Made to the Draft Brush Control Plan

General Changes

1. A bibliography and foot notes will be added
2. All tables will be listed and numbered
3. Page numbers will be assigned to all sections in the Table of Contents
4. All spelling, gramatical and typographical errors noted in the comments will be corrected
5. The Board will consider the inclusion of criteria developed by the Texas Parks and Wildlife Department as an attachment to the plan. Other material on subjects pertinent to the plan may be included as attachments in the future. Any information attached to the plan will receive consideration by the Board in reviewing project applications and in project planning and development.
6. We would point out that research needs are addressed in the plan and are considered a part of the plan. As research is completed and results are published, these findings will be incorporated in the plan.

Specific Changes

Page 31 - Delete section on Hardwoods. Place individual species of Ash and Elm under miscellaneous trees on page 32. Include under treatment of miscellaneous trees dozing and spraying.

Page 55 - (sentence 7 from the top) - change noneconomic plants to brush and weeds.

Page 56 and 57 - (last sentence on page 56 and first sentence on page

57) - change to read "Examples such as Rocky Creek west of San Angelo combined with research data from other states has given rise to the logical assumption that increased water yield is possible through brush management and sound conservation.

Page 63 - (delete 4 - add the following) - Research is also needed in determining the relationships between various levels of brush management and domestic animal, wildlife and plant populations so that the effects of practice installation can be more accurately predicted.

Page 85 - (number 16) - change ratio both places it is used to comparison.

Page 90 - (number 4 - last sentence on page) - delete potential.

Page 99 - (after third paragraph add) - Section 203.159 of the law states that the Board shall give more favorable consideration to a particular project if the applicants individually or collectively agree to increase their percentage share of costs under the cost-share arrangement.

Page 101 - (last sentence, first paragraph) - add project to the end of the sentence.

Page 102 - (sixth line from the bottom) - Rewrite sentence to read - Design of the mosaic should create patterns that allow the treated segment to carry its own populations of wildlife and contribute to the diversity of the habitat in the surroundings.

(2) Change the word game to wildlife as it occurs on the page.

Page 103 - change the word game to wildlife as it occurs on the page.

Page 109(1) - (9.6 Individual landowner plans) - After the first sentence add the following: All individual applications will be submitted to the soil and water conservation district whose boundaries include the land where the plan will be carried out.

(2) (9.6 - fifth line) - change the word case to applicant

(3) (9.6 - sixth line) - change the word needed to approved

Page 110 - (list additional points to be included in the operators plan) - (8) plans for maintenance; (9) proof of financial ability; (10) other pertinent information considered necessary by the Board

Page 111 - (10.1 State Board Role - after line seven begin a new paragraph and add the following:)

Section 203.154. of the law states that:

(a) Not more than 70 percent of the total cost of a single brush control project may be made available as the state's share in cost sharing.

(b) A person is not eligible to participate in the state brush control program or to receive money from the state brush control program if the person is simultaneously receiving any cost-share money for brush control on the same acreage from a federal government program.

(c) The board may grant an exception to Subsection (b) of this section if the board finds that joint participation of the state brush control program and any federal brush control program will:

(1) enhance the efficiency and effectiveness of a project; and

(2) lessen the state's financial commitment to the project.

Section 203.155. Limit to Critical Areas and Approved Methods Cost sharing under this subchapter is available only for projects that:

(1) are implemented in critical areas as designated by the board;

(2) use a method of brush control approved under Section 203.055 of this code.

Page 113 - (Add the following paragraph to Section 10.1)

Reapplication of practices that initially fail to achieve acceptable results or deteriorate after achieving the desired results may be allowed and cost share provided. Approval of cost share funds for reapplication of practices may be allowed provided that:

(a) The specifications for the practice were met in the original application

(b) The failure or deterioration was due to conditions and circumstances beyond the control of the producer.