5A.9 Brush Control and Range Management

5A.9.1 Description of Option

Virtually all of the renewable and sustainable water resources available for the Brazos G Region originates as precipitation within the boundaries of the region. The inflow from the upstream tributaries of the Brazos River is limited in amount and quality. The significant majority of this precipitation falls on agricultural lands, which includes crop land, improved pastures, improved range, native range, and other rural lands, such as rocky outcrops, heavy brush and trees, and other land that is not used for production. In an oversimplified explanation of the hydrologic cycle, there are three possibilities for the precipitation that falls on land:

1. Surface runoff,
2. Infiltration, or
3. Evaporation.

The water that has infiltrated the soil has four possible routes after the rainfall or snowmelt event has ended, the landscape has dried, and the runoff has ended:

1. The soil water may restore the soil to field capacity (saturate the soil),
2. The soil water in excess of field capacity will recharge lower soil zones and percolate to the groundwater table,
3. The soil water may be extracted by plant roots as transpiration to the atmosphere, or
4. The soil water may move by capillary action to the soil surface and evaporate to the atmosphere.

The partitioning of the rainfall or melted snow water to the various routes is highly variable, depending on soil type, hydrologic condition, slope, and vegetative cover as the four dominant factors. Of these four, all but slope can be modified by management practices, and the effects of slope can be managed to an extent with diversion channels and terraces.

The primary goal of runoff management practices in agriculture and flood control is to reduce the immediate surface runoff from a rainfall event. In hydrologic terms, this is known as decreasing the peak of the hydrograph—the peak volume of flow from a watershed is reduced. High peak volumes contribute to flooding, increased design size of structures (e.g., bridges and channels), and soil erosion. Floodwater that moves off of a landscape is not available for plant growth and groundwater recharge. The runoff will restore reservoirs to their capacity, but high floodwater will be passed downstream when storage capacities of reservoirs and channels is reached. Better water management options are to reduce the flood peak and promote a much longer period of runoff from various storage options (e.g., P.L.566 flood control reservoirs, stock ponds, channels, soil, and groundwater).

Land surface treatment methods that reduce the peak volume of runoff also increase the infiltration into the soil. The sensitivity of peak flow to the landscape is shown by the variation of coefficients in the Rational Formula, which has been in use for about 150 years to predict the peak flow from small watersheds. The formula is:

$$Q = CiA,$$

Where:

Q = peak flow (in cubic feet per second),
i = rainfall intensity (in inches per hour), and
A = area (in acres) (1 acre inch per hour is equal to 1.008 cubic feet per second).

The coefficient, C, is dependent on land use, slope, vegetation, and soil type. C ranges from 0.95 for paved parking lots to 0.10 for heavily-vegetated, flat, sandy areas. Hilly, bare, clay soils have a C of 0.82. Other factors being equal, the presence of a vegetated cover (such as grass) instead of a bare soil surface decreases the C, and thus the peak runoff rate, by one- to two-thirds. A number of more sophisticated equations and models are available to compute the total runoff from all major landscape combinations. The factors that affect runoff and infiltration are much the same, however. The main point is that modification of the landscape has a significant impact on the partitioning of rainfall into runoff and infiltration.

Agricultural producers have an arsenal of soil and water conservation practices that reduce peak runoff, increase infiltration, and reduce soil erosion. Many of these practices focus on the development of vegetative cover for the soil surface.

From a water yield standpoint, the ideal range (non-cropland) landscape has a good grass and cover at all times of the year, whether the grass is alive or dormant. The grass retards surface runoff and allows more opportunity time for infiltration of the rainfall into the soil. The grass prevents sealing of the soil surface and the roots improve the soil structure, which also increases infiltration (water flow *into* the soil) and percolation (water flow *within* the soil). The active root zone of most grasses is easily within the top 3 feet of the soil, so the infiltrated soil water that is in excess to the storage capacity of the soil will percolate to the groundwater table.

In aquifer outcrop areas, this percolation recharges the aquifer. If there is no aquifer, the shallow groundwater will emerge as springs and soil water movement into creek, stream, and river channels. This is the source of the highly desirable base flow of rivers that continuously recharge the reservoirs and provide wildlife habitat, livestock water, fish habitat, and recreational uses. Flash flood runoff does not contribute significantly to this base flow. The grass cover provides grazing for stock, which provides the economic incentive for the landowner to maintain the ranges in good condition.

The worst case from a water yield standpoint is a landscape that is covered with brush, such as juniper and mesquite. The grass cover is reduced under the brush (especially juniper) and, therefore, not fully effective in reducing runoff. The major impact of the brush, however, is the continuing extraction of soil water for transpiration long after the rainfall event has ended. Whereas most grasses have an effective rooting zone of 3 feet or less, mesquite can pull moisture from 10 to 20 feet and perhaps even more. Juniper is much shallower rooted, but will still extract moisture from below the grass root zone. One report likens this to millions of plants with soda straws into the groundwater. Although each fair-sized shrub or small tree (10-foot diameter canopy) would only use 10 to 15 gallons of water a day, it would use the water every day and all of the water use for an area adds to a significant amount of groundwater consumed. Grass, with its much shallower root zone, is limited by the amount of soil water available for extraction.

Conversion of large areas of brush to grassland, without necessarily removing trees or the amount of brush needed for wildlife habitat, cattle shade, or aesthetics, has an impact on water yield. The major effect is the reduction of water removed from the groundwater and the soil below the rooting zone of most grasses. A lesser effect is the increased runoff during rainfall and snowmelt events.

5A.9.1.1 General Brush Control and Range Management Background

Very little, if any, of brush control research for either range management or water yield has been conducted in the Brazos G Region. Most brush control research in similar landscapes has been conducted in the areas adjacent to the Texas A&M University Research and Extension Center at Vernon and the Texas A&M University Research and Extension Center at San Angelo. The most feasible areas in terms of implementation will be those areas that are now used or are otherwise suitable for grazing by sheep or cattle. Deforestation of scenic Hill Country or heavily wooded areas is neither feasible nor reasonable. Riparian zone vegetation, with the possible exception of salt cedar, similarly is not considered for removal.

The Department of Rangeland Ecology and Management at Texas A&M University has conducted extensive research statewide in brush control for several decades. The following paragraphs have been extracted from a report by Dr. Richard Conner for the Rio Grande Regional Water Planning Group.

The use of water resources by primarily brush species is not known with certainty, but numerous studies demonstrate that in many cases, such usage is dramatic. Estimates by the USDA-NRCS show that more than 57 percent of all water needs in Texas could be solved by water yielded from brush control. Other studies indicate that 38 percent, or more, of annual rainfall is consumed by excess brush species.

Research on brush control and water balance began in the 1920s, but the idea of brush control as a possible means of alleviating water scarcity in drought-prone western states started to take hold in the 1970s. The control of brush species yields more water, but is dependent upon rainfall variations and many other landscape variables. However, past research has predicted that the removal of woody species from rangeland can yield an additional 0.3 inches of surface flow water for each inch of annual precipitation above 15 inches. This is possible where deep-rooted brush species are replaced with shallow-rooted, deciduous, low-biomass herbaceous species.

Groundwater initially receives most of the additional water that is produced from brush removal, although surface water flows may be enhanced directly and indirectly following initial groundwater recharge. The rate of brush regrowth and brush control maintenance is important to maintaining stable, long-term water yield. Control methods that kill and remove the entire brush plant are more desirable than simply killing the brush. Water yield projections usually exceed actual results, and optimum results are achieved under optimum conditions. A growing body of information on the hydrological aspects of rangelands has produced mixed results to the question of water production, but in general, point to positive outcomes to carefully planned brush control. One such study points out that increased water production is likely to be limited to years with above-normal winter and spring precipitation.

An initial study of the feasibility of brush control for water yield was undertaken in 1998 on the North Concho River near San Angelo. This study was in response to other successful efforts undertaken on Rocky Creek of the Middle Concho River and Seco Creek in the Medina River Basin. This process of analysis was undertaken as a joint project of the Upper Colorado River Authority, the Texas Agricultural Experiment Station, and the Texas Agricultural Extension Service.

The project used land-satellite imagery, with minimal ground-truth, to determine brush coverage by class. This information was used to both determine potential water yield and economic benefits and costs. The process used in the project determined water yields via the Soil and Water Assessment Tool (SWAT). Finally, costs and benefits were discovered by budgeting existing agriculture efforts on brush infested lands and evaluating the ability of ranchers to participate in brush control by cost-sharing with the state of Texas.

The potential to enhance off-site water yield depends on the presence of brush, and soil and plant community relationships that respond with additional water yield when brush is removed. Further, the potential for society to benefit from any enhanced water yield produced by removing the brush depends on the presence of reservoirs for surface water or a rechargeable groundwater aquifer which will effectively store water for later use.

5A.9.1.2 Mechanical Brush Control

A wide variety of mechanical brush control methods are available. The simplest is selective brush control with a hand axe and chain saw. Grubbing and piling is frequently done with a bulldozer. This may be either clear-cut or selective. Bulldozers and/or tractors may also be equipped with root plows, shears, or shredders. Two large bulldozers pulling large anchor chains stretched between them are capable of clearing low brush in swaths 100 foot or more in width at a time.

Moderate to heavy mesquite or cedar can be grubbed (bulldozer with a 3-foot-wide grubbing attachment) for $50 to $150/acre. It can also be root plowed for about $75 to $90/acre, but root plowed areas should be re-seeded and this costs about another $25 to $30/acre. Reseeding is a risky business (fair to good probability of a seeding failure).

Two-way chaining can be effective on moderate to heavy cedar, costing $15 to $18/acre, but it often just breaks off mesquite and they re-sprout profusely from the bud zones below ground.

Using hydraulic shears mounted on Bobcat loaders can be effective on blueberry juniper (a non-sprouting species) for a cost of $50 to $140/acre. If the shears are used on mesquite or redberry juniper one must spray the stump immediately with a herbicide, which will cost in the range of $0.10 to $0.30 per plant.

5A.9.1.3 Chemical Brush Control

Several herbicides are approved for brush control. The herbicides may be applied by applying a herbicide-water mixture from aircraft, from booms on tractor-pulled spray rigs, or from hand tanks. Some herbicides are also available in pellet form.

The only herbicide mixture that will be cost-shared in the North Concho project (on our recommendation) is Remedy at 0.25-pound active ingredient per acre plus Reclaim at 0.25-pound active ingredient per acre. This is equivalent to one-half pint of Remedy per acre and two-thirds pint Reclaim per acre. This is the “Cadillac” treatment for mesquite control, achieving about 70 percent root kill in 12 to 15 studies around the state and in adjacent states. Commercial aerial applications in general are not this effective, probably because the applicators and the landowners don’t pay enough attention to “timing” and other criteria. Timing is the key to success; soil temperature at 12 to 18 inches must be over 75°F, preferably at least 80°F. Mesquite foliage must be dark green. There are a couple of specific times that are best, including 42 to 63 days after bud break and 72 to 84 days after bud break, that give best root kill because carbohydrates are being translocated downward into the mesquite bud zones and roots. The herbicides are translocated with the carbohydrates down into the roots and perenniating buds below the soil surface. One can spray for much less money with other herbicide treatments, but they will achieve little root kill.

Pricklypear can be aerially sprayed with 0.5 pounds active ingredient per acre of picloram (Tordon 22K) for about $20 to $24 per acre (1 quart of Tordon 22K per acre). The best time for aerial application of picloram to control pricklypear is late summer or fall.

Aerial spraying brush such as mesquite costs the same regardless of the plant density or canopy cover, about $22 to $23 per acre (three aerial applicators say that this is the price they will be charging for spraying mesquite in the North Concho River watershed brush control project).

5A.9.1.4 Brush Control by Prescribed Burning

Prescribed burning is defined as the application of fire to a predetermined area. The burn is conducted under prescribed conditions of fine fuel load, weather, and season to specifically target desired effects. The purposes of prescribed burning include control or suppression of undesirable vegetation, facilitation of distribution of grazing and browsing animals, improvement of forage production and/or quality, and improvement of wildlife habitat.

Prescribed burning can be done for $2.50 to $7.50 per acre, depending on how rocky the soils are and how much large brush must be removed from the fire guards (i.e., a once-over pass with a maintainer versus clearing heavy brush with a bulldozer, then smoothing up the fire guard). Prescribed burning will only be effective if it is done under the right environmental conditions, and with an adequate amount of fine fuel (dead or dormant grasses). Most often a pasture deferment is essential for part or all of the growing season prior to burning, and burned pastures must be rested some after the burn. On average, almost a 12-month deferment is necessary, and this adds more cost if the rancher has to lease grazing for his livestock. Grazing leases usually go for about $8 to $10 per animal unit per month. Burning rarely affects moderate to heavy stands of mature mesquite. Burning only topkills the smooth-bark mesquite plants, and they re-sprout profusely. For mesquite, fire only gives short-term suppression and it stimulates the development of heavier canopy cover than was present pre-burn because topkilled plants come back with many basal stems. Fire is not usually an applicable tool in moderate to heavy cedar (juniper) because these stands suppress production of an adequate amount of grass for fine fuel. Fire can be excellent for controlling junipers over 4 feet tall, if done correctly.

Intense fires give 50 to 85 percent reduction in live pricklypear cover, but a fairly high percentage of the plants re-sprout. Summer burns are much more effective than winter burns for killing pricklypear, but they're also much more dangerous. Winter burns followed by aerial application of Tordon 22K (picloram) at one-half to 1 pint per acre are extremely well liked in this region by ranchers. This usually gives over 95 percent reduction in prickly pear, for a cost of about $15 per acre.

5A.9.1.5 Range Management for Brush Control

Grazing management is a <u>must</u> following any type of brush control - to allow the desirable forages to exert their maximum potential competition with the brush plants and to maintain good herbaceous groundcover to hinder establishment of woody plant seedlings. Landowners who are not willing to manage their grazing probably should not spend money on brush control.

5A.9.2 Water Yield from Brush Control

Theoretically and scientifically, control of brush will increase water yield. Given the variability of annual rainfall and the variability of runoff from individual rainfall events, it will require several years of monitoring a watershed or paired watersheds to establish the water yield from brush control. A substantial body of evidence does show the effects of increasing brush infestation on water yield, however.

Over 40 individuals from over a dozen agencies, including the Upper Colorado River Authority, the Texas Agricultural Experiment Station, and the Texas Agricultural Extension Service, cooperated in the North Concho River Watershed brush control feasibility study. The watershed covers 950,000 acres within Tom Green, Sterling, Glasscock, and Coke Counties. The North Concho terminates in the O.C. Fisher Reservoir, immediately above San Angelo. The reservoir was constructed in the 1950s for water supply, but the performance has been below expectations.

Interviews with "old-timers" and searches of historical records show that a significant invasion of mesquite in the lower elevations and juniper in the higher elevations occurred in the 1950s. Estimates of the brush populations show over 130 million mesquite and 100 million juniper. Satellite imagery shows about 45 percent of the watershed could benefit from brush control. The drought and overgrazing contributed to a very rapid spread of the slowly encroaching brush. The changes in streamflow are dramatic. The official USGS stream measuring station showed an annual average streamflow of 38,617 acft of water for the period 1925 to 1959. After 1959, the annual average streamflow was only 8,358 acft of water. The average annual rainfall was 19.48 inches from 1925 through 1959 and 20.31 inches from 1960 through 1996. The difference is over 30,000 acft of water each year from about the same rainfall. Not all of this difference can be attributed to the invasion of mesquite and juniper, however. Irrigation from deep wells expanded rapidly after the drought of the 1950s. The irrigated acreage in the four counties of the watershed was about 22,000 acres in 1958 and 99,000 acres in 1994. The irrigation withdrawal in 1994 was 165,000 acft. Most of the irrigation is reportedly to the southeast of the North Concho watershed, but the Edwards-Trinity Aquifer dips to the southeast. However, with the assumption that the report is essentially valid, the potential for increased water yield from brush control is significant. The brush control cost averages $53 per acft of water over a 10-year period.

5A.9.3 Environmental Issues

5A.9.3.1 Air Emissions and Air Pollution

The Texas Natural Resource Conservation Commission allows outdoor burning if there is no practical alternative and if the burning will not cause or contribute to a nuisance, traffic hazard, or a violation of a primary or secondary ambient air standard (Chapter 111). Prescribed burning is authorized only when weather conditions are favorable. Smoke and other pollutants will not cause adverse affects to any public road, landing strip, navigable water, or off-site structure containing sensitive receptors.

Prescribed burning, conducted under a plan developed by the Natural Resources Conservation Service or the Texas Agricultural Extension Service, will take these factors into account prior to the burn.

5A.9.3.2 Endangered Species

Brush control could impact the habitat, both positively and negatively, of two songbirds protected by the Endangered Species Act. The golden-cheeked warbler and the black-capped vireo inhabit some brush country of the Edwards Plateau and the Cross Timbers and Prairies in Brazos G, primarily to the northwest of IH-35.

5A.9.3.2.1 Black-capped Vireo

The vireo habitat in Brazos G is listed in Bell, Bosque, Coryell, Erath, Hamilton, Lampasas, Nolan, Somervell, Taylor, and Williamson Counties. Vireos typically nest in shrublands and open woodlands with a distinctive patchy structure covering 30 to 60 percent of the total area. Open grassland surrounds the clumps of shrubs and trees with abundant low cover (below 6 feet). Rangelands composed primarily of mesquite are not considered vireo habitat. Preferred nesting areas usually have a low density and cover of juniper. The black-capped vireos arrive in Texas from mid-March to mid-April to nest. They begin to depart in July and are gone by mid-September.

Prescribed burning is an excellent tool to maintain the desired vegetation structure for vireo nesting, according to the Texas Parks and Wildlife Department.[1] Cool season burns before March 15 are often recommended to control small juniper, thus maintaining the relatively open shrublands preferred for nesting. Warm season burns should not be done in areas that support the vireos. Prescribed burns conducted under hotter conditions can be used to set back plant succession in order to create vireo habitat. On grazed rangeland, prescribed burns should be coordinated with livestock rotation to allow for needed deferments. Burning intervals of 4 to 7 years are desirable to keep juniper invasion in check and to allow regrowth of broad-leaved shrubs.

Selective brush control with herbicides or mechanical means can be used to maintain suitable habitat for vireo nesting. Removal of juniper, mesquite, and pricklypear will maintain a relatively open shrub canopy. Handcutting or carefully planned mechanical methods of brush management, such as roller chopping, chaining, and shredding can be used to stimulate basal sprouting of key woody shrubs and trees. This should only be done during the time of year when the vireos are not present.

Grazing as a follow-up to brush management should be carefully managed. Excessive grazing by goats and white-tailed deer destroys the thick woody growth needed for nest concealment. Woody plants should receive only limited browsing during the summer. Cattle grazing is beneficial to vireo habitat.

5A.9.3.2.2 Golden-cheeked Warbler

The golden-cheeked warbler habitat in Brazos G is in Bell, Bosque, Comanche, Coryell, Eastland, Erath, Hamilton, Hood, Johnson, Lampasas, McLennan, Palo Pinto, Somervell, Stephens, and Williamson Counties. The warblers typically nest in tall, dense, mature stands of juniper mixed with broadleafed trees. The habitat is generally in relatively moist areas such as steep-sided canyons and slopes. The mix of juniper and deciduous trees on slopes, along drainage bottoms, and in creeks and draws provides an ideal mix of vegetation for the habitat. Not all of these favorable mixes of vegetation are used by the warblers, so is not subject to protection by the Endangered Species Act. Preferred nesting sites usually have a high proportion

[1] Texas Parks & Wildlife Department (TPWD), “Black-capped vireo,” Pamphlet, TPWD, Austin, Texas, 35 p., 1996.

of mature juniper. Golden-cheeked warblers arrive in Texas in early to mid-March and return to Latin America from late June to mid August.

Brush control ordinarily does not impact golden-cheeked warbler habitat because the preferred nesting sites would not benefit from brush removal.[2] Clearing the mature trees has a very high cost and does not result in land with a good grazing or agricultural potential. Greater threats to the habitat are posed by suburban development. Fencing and other ranch improvement work should be planned for the times of year when the warblers are not present.

5A.9.4 Options and Cost Estimates

To estimate the costs and expected yield in added off-site water, information was used from the recent studies on the North Concho River and Frio River basins. The Frio River basis study reveled that on those range sites that produced increased runoff following brush control (the sandy textured soil types) the average annual increase was 0.032 cm per year per unit area subjected to 50 percent brush control. When this yield is proportionally extended to an amount that would be expected with 95 percent of the brush controlled, it equals 0.02 acft per acre per year. Present value of the state's share of cost of brush control (and maintenance for 10 years) based on costs used in the North Concho study was $30.51 per acre. Assuming a 10-year project life and a 4 percent discount rate, these costs and yields would result in an estimated $187.64 total off-site water cost per acft over the project life.

Alternatively, the North Concho study estimated added off-site water yield from brush control to average 0.076 acft/yr per acre controlled across all range sites. These yield estimates, with the $30.51 per acre cost, would result in an estimated $49.38 total off-site water cost per acft over the project, again assuming a 10-year project life and a 4 percent discount rate.

Bach and Conner prepared a detailed analysis of brush control practices for increased water yield for the North Concho River.[3] The majority of their report is presented in this section.

Economic Analysis of Brush Control in the North Concho: Land cover categories identified and quantified for the North Concho River Basin by Walker, et al.[4] included four brush

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[2] TPWD, "Golden-cheeked Warbler," Pamphlet, TPWD, Austin, Texas, 27 p., 1996.
[3] Bach, Joel P. and J. Richard Conner, "Economic Analysis of Brush Control Practices for Increased Water Yield: The North Concho River Example," In: Proceedings of the 25th Water for Texas Conference - Water Planning Strategies for Senate Bill 1, R. Jensen, ed., Texas Water Resources Institute, College Station TX, pp. 209-217, 1998.
[4] Walker, J., W. Dugas, F. Baird, S. Bednarz, R. Muttiah and R. Hicks, "Site Selection for Publicly-Funded Brush Control to Enhance Water Yield," In: Proceedings of the 25th Water for Texas Conference - Water Planning Strategies for Senate Bill 1, R. Jensen, ed., Texas Water Resources Institute, College Station TX, 1998.

type-density categories: heavy mesquite, heavy cedar (juniper), moderate (mixed) brush, and light (mixed) brush. For purposes of estimating total costs, rancher participation, and the amount of cost-share that would be required of the state, a total of six species-based type-density categories were delineated from the four identified by Walker et al.[5] These are heavy mesquite, heavy cedar, moderate mesquite, moderate cedar, light mesquite and light cedar.

Brush control practices include initial and follow-up treatments required to reduce the current canopies of all categories of brush types and densities to 3 to 8 percent and maintain it at the reduced level for at least 10 years. These practices, or brush control treatments, are outlined in Table 5A.9-1. The control practices and their impacts on plant communities and herbaceous growth represent a consensus of expert opinion obtained through discussions with Texas Agricultural Experiment Station Scientists, Texas Agricultural Extension Service Specialists, and USDA-NRCS Rangeland Management Specialists with extensive brush control experience in the project area.

Year 0 in Table 5A.9-1 is the year that the initial practice is applied, while years 1 through 9 refer to the number of years following the initial practice. Increases in water yield that would be expected with brush control were only estimated for the heavy and moderate categories. Brush control treatments and costs for light mesquite and cedar are included because it is expected that without control, these categories of brush would continue to expand so that within 10 years they would reach higher density categories.

Control Costs: Costs and the present value of costs for the brush control practices (assuming an 8 percent discount rate-opportunity cost for rancher investment capital) are also displayed in Table 5A.9-1. Obviously, the costs vary with the brush type-density categories. Present values of control programs are used for comparison since some of the treatments will be required in the first year to initiate the program while others will not be needed until year 6 or year 7. Present values of total per acre control costs range from $12.92 for light mesquite that can be initially controlled with individual plant herbicide treatments to $75.42 for heavy cedar that cannot be controlled with two-way chaining but must be initially controlled with mechanical tree bulldozing.

[5] Walker, J., et al, Op. Cit., 1998.

Table 5A.9-1.
North Concho Water Yield Brush Control Programs by Type-Density Category

Year	Treatment Description	Cost/Unit	Present Value
Treatment #1 – Heavy Mesquite			
0	Aerial Spray Herbicide	36.00	36.00
2	Chemical IPT[1]	15.00	12.86
7	Chemical IPT or Prescribed Burn	8.60	5.02
		Total:	$53.88
Treatment #2a — Heavy Cedar			
0	Tree Doze and Burn	70.00	70.00
6	Chemical IPT or Prescribed Burn	8.60	5.42
		Total	$75.42
Treatment #2b — Heavy Cedar			
0	Two-Way Chain	15.00	15.00
1	Prescribed Burn for Slash Reduction	8.60	7.96
7	Chemical IPT or Prescribed Burn	8.60	5.02
		Total	$27.98
Treatment #3 — Moderate Mesquite			
0	Chemical IPT	15.00	15.00
6	Chemical IPT or Prescribed Burn	8.60	5.42
		Total	$20.42
Treatment #4 — Moderate Cedar			
0	Chemical or Mechanical IPT	20.00	20.00
6	Chem/Mech IPT or Prescribed Burn	8.60	5.42
		Total	$25.42
Treatment #5 — Light Mesquite			
0	Chemical IPT	7.50	7.50
6	Chemical IPT or Prescribed Burn	8.60	5.42
		Total	$12.92
Treatment #6 — Light Cedar			
0	Chemical or Mechanical IPT	10.00	10.00
6	Chem/Mech IPT or Prescribed Burn	8.60	5.42
		Total	$15.42

Rancher Benefits From Brush Control: One objective of the analysis is to equate rancher benefits with rancher costs. Therefore, the task of discovering rancher cost for the brush control was reduced to estimating the benefits that would be expected to accrue to any rancher participating in the program. These benefits are based on the present value of the improved net returns made available to the ranching operation through increases or expansions of the typical cattle, sheep and wildlife enterprises that would be reasonably expected to result from implementation of the brush control program. For the livestock enterprises, an improvement in net returns would result from increased amounts of usable forage produced by controlling the brush and thus eliminating much of the competition for water and nutrients within the plant communities on which the enterprise is based.

As with the brush control practices, the grazing capacity estimates represent a consensus of expert opinion obtained through discussions with TAES Scientists, and TAEX Specialists, and USDA-NRCS Rangeland Management Specialists with brush control experience in the North Concho area. Because of differences in soils and climate, livestock grazing capacities differ by location within the basin. It was determined that these physical differences had two primary geographical areas.

In the portion northwest of Sterling City (NW), carrying capacities range from about 14 animal units per section for land infested with heavy cedar to about 25 animal units for land on which mesquite is controlled. Southeast of Sterling City (SE), the grazing capacities range from about 18 animal units per section for land infested with heavy cedar to about 34 animal units for land on which mesquite has been controlled.

Livestock production practices, revenues, and costs representative of the northwest and southeast portions of the basin were obtained from personal interviews with focus groups of local ranchers. Estimates of the variable costs and returns associated with the livestock and wildlife enterprises typical of each area were then developed from this information into production-based investment analysis budgets. From these budgets, baseline data was entered into the investment analysis model.

Rancher benefits were also calculated for changes in existing wildlife operations. Most of these operations were determined to be simple hunting leases with deer, turkeys, and quail being the most commonly hunted species. Therefore, wildlife costs and revenues were entered into the model as simple entries in the project period. For control of heavy mesquite and cedar, wildlife revenues are expected to increase by about $0.50 per acre due principally to the resulting improvement in quail habitat. Wildlife revenues would not be expected to change with implementation of brush control for the moderate or light brush type-density categories.

For ranchers to benefit from the improved forage production resulting from brush control, livestock numbers must be changed as grazing capacity changes. In this study, it was assumed that ranchers would adjust livestock numbers to match grazing capacity changes on an annual basis. Annual benefits that result from brush control were measured as the net differences in annual revenue (added annual revenues minus added annualized costs) that would be expected with brush control as compared to without brush control.

These annual estimates of net revenue differences were discounted (an 8 percent discount rate-opportunity cost for rancher investment capital was used) and summed to get an estimate of the net present value of rancher benefits over the 10-year planning period for each brush category type for both areas of the basin. An example of this process is shown in Table 5A.9-2 for the control of heavy mesquite in the NW portion of the North Concho watershed.

Table 5A.9-2.
Net Present Value
Northeast North Concho for Control of Heavy Mesquite

Added Units Due to Investment in Brush Control
(All Units in Dollars, Except Animal Units)

Year	Animal Units (AU)	Sales	Investment	Costs	Wildlife Revenues	Cash Flow	Annual NPV	Accumulated NPV
0	0.2	0	0	0	0	0	0	0
1	3.5	1,312	1,890	424	0	-1,002	-928	-928
2	6.9	2,690	1,260	759	0	671	575	-353
3	8.8	3,413	980	985	500	1,948	1,546	1,194
4	9.1	3,413	0	985	500	2,928	2,152	3,346
5	9.3	3,480	0	985	500	2,995	2,038	5,384
6	9.6	3,547	0	985	500	3,062	1,929	7,313
7	9.9	3,547	0	985	500	3,062	1,787	9,100
8	10.1	3,614	0	985	500	3,129	1,690	10,790
9	10.4	3,681	0	985	500	3,196	1,599	12,389
					Salvage Value	$4,130	$2,066	$14,455

This analysis of rancher benefits was done by analyzing a theoretical 1,000-acre management unit that was to represent a standard for the economic analysis. To get per acre benefits, the accumulated net present value of $14,455 shown in Table 5A.9-2 must be divided by 1,000, which results in $14.46 as the estimated present value of the per acre net benefit to a rancher.

The resulting net benefit estimates for all of the type-density categories for the NW and SE portions of the basin are shown in Table 5A.9-3. Present values of these benefits differ by location within the basin. In the SE portion they range from $5.62 per acre for control of light mesquite to $19.40 per acre for control of heavy cedar. In the NW portion they range from $4.58 per acre for control of light cedar to $17.08 per acre for control of heavy cedar.

Table 5A.9-3. Present Value of Costs for Brush Control Investment in Dollars per Acre

Brush (Type and Density)	***Rancher Cost Share***	***Percent***	***State Cost Share***	***Percent***	***Total Cost***
Southeastern Part – North Concho River					
Heavy Mesquite	16.06	29.81	37.82	70.19	53.88
Heavy Cedar (TD)[1]	19.40	25.72	56.02	74.28	75.42
Heavy Cedar (2CB)[2]	19.40	69.34	8.58	30.66	27.98
Moderate Mesquite	8.35	38.15	12.07	61.85	20.42
Moderate Cedar	10.06	39.58	15.36	60.42	25.42
Light Mesquite	5.62	43.50	7.30	56.50	12.92
Light Cedar	5.87	38.07	9.55	61.93	15.42
Average	—	40.60%	—	59.40%	—
Northwestern Part – North Concho River					
Heavy Mesquite	14.46	26.84	39.42	73.16	53.88
Heavy Cedar (TD)[1]	17.08	22.65	58.34	77.35	75.42
Heavy Cedar (2CB)[2]	17.08	61.04	10.90	38.96	27.98
Moderate Mesquite	7.55	36.97	12.87	63.03	20.42
Moderate Cedar	7.53	29.62	17.89	70.38	25.42
Light Mesquite	4.97	38.47	7.95	61.53	12.92
Light Cedar	4.58	29.70	10.84	70.30	15.42
Average	—	35.04%	—	64.96%	—

1 Controlled by tree dozing. This heavy cedar has too small a trunk diameter to effectively clear with chaining (<4” diameter).
2 Controlled by 2-way chaining followed by prescribed burning. This heavy cedar has larger trunks (>4” diameter).

State Cost Share: If ranchers are not to benefit from the state's portion of the control cost, they must invest in the implementation of the brush control program an amount equal to their total net benefits. The total benefits that are expected to accrue to the rancher from implementation of a brush control program are equal to the maximum amount that a profit maximizing rancher could be expected to spend on a brush control program (for a specific brush density category).

Using this logic, the state cost share is estimated as the difference between the present value of the total cost per acre of the control program and the present value of the rancher participation. Present values of the state cost share per acre of brush controlled in the SE range from $8.58 for control of heavy cedar with two-way chaining and burning to $56.02 for control of heavy cedar with tree dozing. In the NW, the state cost share ranges from $10.90 to $58.34 for the same control practices. Total treatment cost, rancher participation or cost-share, and state cost-share for all brush type-density categories are shown in Table 5A.9-3.

The costs to the state include only the cost for the state's cost share for brush control. Costs that are not accounted for, but which must be incurred, include costs for administering the program. Under current law, this task will be the responsibility of the Texas State Soil and Water Conservation Board.

Cost of Additional Water: The total cost of additional water is determined by dividing the total state cost share (if all eligible acreage were enrolled in the program) by the total added water estimated to result from the brush control program over the assumed ten-year life of the program. This figure is adjusted for the differences in time of water availability and time of cost share expenditures. As was mentioned above, added water from brush control was only estimated for the heavy and moderate categories. The water yields resulting from the brush control program and the estimated acreage eligible for enrolling in the program discussed above are used to estimate the average annual added water yields for each brush type-density category. Likewise, the total state cost share for these two categories is estimated by multiplying the per acre state cost share for each brush type-density category by the eligible acreage in each category.

The cost of added water resulting from the control of each brush type-density category is then estimated by adjusting the water yields for the delay in time of availability over the 10-year period, summing them, and then dividing them into the total state cost. By this technique, the cost of added water averages $49.75 per acft for the entire North Concho basin and ranges from $47.29 per acft for the NW portion to $51.72 per acft for the southeast portion. Details of the costs of added water for the different brush type-density categories and different sections of the basin are shown in Table 5A.9-4.

Table 5A.9-4.
Estimated Cost to State of Brush Control and Total Added Water Yield per Year With 100 percent Enrollment of Eligible Acres

Southeastern (SE) Part of North Concho Basin				
Brush Type-Density	***Heavy Mesquite***	***Heavy Cedar***	***Moderate Brush***	***Total***
Category acreage	109,773	56,973	31,744	198,490
Present value of state cost share per acre ($)	37.82	32.30[1]	13.72[2]	32.39[3]
Present value of total cost if all enrolled (millions $)	4.15	1.84	0.44	6.43
Acre-feet added water per acre per year	.081	.076	.067	.077[3]
Total possible added water per year	8,892	4,330	2,127	15,349
10-year average cost per acft: $51.72[4]				
Northwestern (NW) Part of North Concho Basin				
Brush Type-Density	***Heavy Mesquite***	***Heavy Cedar***	***Moderate Brush***	***Total***
Category acreage	47,027	53,107	66,816	166,950
Present value of state cost share per acre ($)	39.42	34.621	15.422	28.273
Present value of total cost if all enrolled (millions $)	1.85	1.84	1.03	4.72
Acre-feet added water per acre per year	.081	.076	.067	.0743
Total possible added water per year	3,809	4,036	4,477	12,322
10-year average cost per acft: $47.29[4]				
Total North Concho Basin				
Brush Type-Density	***All Brush***			
Total acreage	365,440			
Present value of state cost share per acre ($)	30.513			
Present value of total cost if all enrolled (millions $)	11.15			
Acre-feet added water per acre per year	.0763			
Total possible added water per year	27,671			
10-year average cost per acft: $49.75				

[1] Cost based on assumption that 50 percent of cedar is cleared with tree dozing and 50 percent with 2-way chaining and burning.
[2] Cost based on assumption that 50 percent of each part cleared is moderate cedar and 50 percent is moderate mesquite.
[3] Weighted (by brush type acreage) average.
[4] Assuming a 4 percent discount rate and a program life of 10 years.

Again, the costs discussed in the previous paragraph only include cost sharing for brush control of the heavy and moderate type-density categories. It could be argued that if the light brush type-density categories are not also controlled, then the estimated 10-year added water yields will not be achieved because the light brush will increase in density and be expected to be in either of the two higher categories by the end of the 10-year period. If the light brush were included in the cost share program and all of the light brush eligible acres were enrolled, it would add another $654,000 to the state's total cost and make the cost of an added acft of water cost $52.65, which is only $2.90 more per acft (Table 5A.9-5).

Table 5A.9-5.
Cost of Including Light Brush Control
in the State Cost Share Program

Location	*Southeast Concho*	*Northwest Concho*	*Total Basin*
Light brush acres	27,568	44,863	72,440
Present value of state cost share ($ per acre)[1]	8.42	9.40	9.03
Present value of total cost (millions $)	0.232	0.422	0.654
Present value of total cost for heavy and moderate brush control (millions $)	—	—	11.15
10-year average cost per acft added water with light brush control	—	—	$ 52.65

[1] Cost based on assumption that 50 percent of each part cleared is light cedar and 50 percent is light mesquite.

Conclusions. The state's 10-year average cost of added water (per acft) does not include the cost of purification and distribution as would be needed if the water were to be used by a municipality such as San Angelo, Midland, or Abilene. To compare this cost to the current cost of similar existing water supplies, one can calculate their annual cost per acft from the investment in their procurement. According to Stephen Brown of the Upper Colorado River Authority (UCRA), the cost of an acft of O.H. Ivie water (available at Lake O.H. Ivie) is $80. An additional $80 per acft is needed for transmission of O.H. Ivie water to the city of San Angelo, where it must still undergo a similar treatment as would water from O.C. Fisher on the North Concho.

Again, according to the UCRA, the City of San Angelo incurs an expense of $.47 per 1,000 gallons for water to be available from Lake O.H. Ivie. This cost does not include a cost for treatment or for the energy to pump the water to the City of San Angelo. At the per acft price found for additional available water in the North Concho River, the per 1,000 gallon price of Concho water would be $0.15. Given these figures for alternative water supplies, the North Concho brush control program appears to be an economically attractive alternative.

5A.9.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 5A.9-6.

Table 5A.9-6.
Comparison of Brush Control and Range Management Option to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply:	
1. Quantity	1. Potential for long-term increased runoff
2. Reliability	2. Reliability is unknown
3. Cost	3. Difficult to establish cost since reliability is unknown
B. Environmental factors	
1. Environmental Water Needs	1. Potential beneficial effect
2. Habitat	2. Effects vary; dependent on species
3. Cultural Resources	3. Negligible impact
4. Bays and Estuaries	4. Potential beneficial effect
C. Impact on Other State Water Resources	• No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	• Beneficial effect on agriculture; see Environment sections for impact on natural resources
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered for benefit to overall water supply, including agriculture and livestock
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

It should be noted that public benefit in the form of additional water depends on landowner participation and proper implementation and maintenance of the appropriate brush control practices. It is also important to understand that rancher participation in a brush control program will primarily depend on the rancher's expected economic consequences resulting from participation. With this in mind, the analyses described in this section are predicated on the objective of limiting rancher costs associated with participation in the program to no more than the benefits that would be expected to accrue to the rancher as a result of participation.

It is explicitly assumed that the difference between the total cost of the brush control practices and the value of landowner-rancher participation would have to be contributed by the state in order to encourage implementation of the brush control practices which result in public benefits in the form of water for public use. Administrative costs (state costs) which would be incurred in implementing, administering and monitoring a brush control project or program are not included in this analysis.

Total state cost and total possible added water discussed above are based on the assumption that 100 percent of the eligible acres in each type-density category would be enrolled in the program. There are several reasons why this will not likely occur. Foremost, there are wildlife considerations. Ranchers will want to leave some brush in strategic locations to provide escape cover and travel lanes for wildlife, especially white tailed deer. It has been suggested that no more than 75 to 85 percent of the brush should be cleared from a given management unit in order to insure maintenance of good wildlife habitat.

Another reason that less than 100 percent of the brush will be enrolled is that many of the tracts where a particular type-density category are located will be so small that it will be infeasible to enroll them in the control program for many different reasons. An additional consideration is found in research work by Thurow, et al.[6] that indicated that only about 66 percent of ranchers surveyed were willing to enroll their land in a similarly characterized program. Based on these considerations, it is reasonable to expect that less than 100 percent of the eligible land will be enrolled, and, therefore, less water will be added each year than is projected. However, it is likewise reasonable that participation can be encouraged by designing the project to include the concerns of the eligible landowners-ranchers. Decreased profitability of sheep/goat and cattle grazing systems will influence the economics of brush control by ranchers, and consequently their willingness to participate.

[6] Thurow, A., T. Thurow, and M. Garriga, "Modeling Texas Ranchers Willingness to Participate in a Brush Control Cost-Sharing Program to Improve Off-Site Water Yields," Journal of Agricultural and Resource Economics, (Manuscript submitted, Department of Rangeland Ecology and Management, Texas A&M University, College Station, TX), 1998.

5A.9.6 References

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