Texas Water Resources Institute

Spring 1988
Volume 14
No. 1

CHANGING THE FACE OF THE RANGE

Will Brush Control Boost Water Yields?

By Ric Jensen
Information Specialist, TWRI

"Often overlooked as an important possible source of saving water is h water wasted by non- economic plants, weeds and woody invaders. These silent thieves are stealing moe water in Texas every yer than is cosume y allth tows all th factoies,nall th agiculual plants."

From H.N. Smith, *Grassland Restoration, Part V, Effect on Water Yield and Supply* (1967)

For a long time, people have considered increasing water yields by removing range plants which may consume large amounts of water and replacing them with grasses which may use less.

Despite this, widescale brush management to increase Texas' water supplies has not occurred. The acreage infested with brush has increased and the problem has worsened.

One of the stumbling blocks keeping brush management from becoming a reality is the complexity of the problem: it is much more complicated than simply chaining a mesquite tree and pulling it out of the ground.

Information is lacking on many aspects of brush control, such as: 1) The amount of water created; 2) Comparative water use of grasses and brush species such as mesquite, saltcedar, juniper, and live oak; and 3) Possible environmental risks such as increased erosion from newly treated areas and disruption of wildlife habitats. Complicating matters is the fact that western states such as Arizona have reported actual water savings less than projected from their brush control programs.

Numerous economic, legal and institutional issues are also unanswered. Someone (a city, a water district, a river authority, the state, or ranchers) must pay for brush removal. The economic value of brush control needs to be identified, and the worth of the additional water supplies needs to be calculated. Ownership of the water developed by such programs is another major issue. As Texas' water laws now stand, an agency sponsoring a brush control project could be successful in increasing water supplies, but may be legally unable to recover the water saved by the program. This is an obstacle that may keep sponsors from becoming involved in brush management.

Many issues concerning this topic were identified in Brushland Management for Water Yield: Prospects for Texas, (McCarl and others, 1987), a special report of The Texas Agricultural Experiment Station (TAES), the agricultural research agency of Texas and part of The Texas A&M University System. TAES researchers are now working to develop data on water usage by brush and range grasses through field experiments at Throckmorton, Uvalde, Vernon, and Alice and are predicting potential impacts of water yields through modeling efforts. Other TAES scientists are investigating the impact of brush control on deer populations and the economics of these programs. Research is also being carried out by scientists at Texas Tech University.

Despite the complexity of the issue and the lack of scientific data, the concept of brush management holds considerable promise for increasing water yields for Texas. Many of the state's major urban areas including Dallas, Fort Worth, Austin, San Antonio, and Corpus Christi are directly dependent on rangeland watersheds for their water supplies. Aquifers such asthe Edwards, Trinity, and Gulf Coast also receive much of their recharge from areas infested with brush. Because brush densities are increasing, such programs may be necessary to maintain current water supplies: a do-nothing approach may result in less water being available in the future.

BASIC FACTS ABOUT MESQUITE

The most prominent brush species in Texas is the honey mesquite, which is found from the Gulf Coast to New Mexico. It is seldom found above 5,500 feet because it is vulnerable to cold weather and does best below 4,500 feet. The plant tolerates full desert heat and survives in areas with 6 to 30 inches of annual rainfall. It grows as tall as 60 feet and can have a trunk three feet in diameter. Mesquite have a dual root system: lateral roots are only a few feet below the surface but spread out 30 feet or more, and a tap root may penetrate as far as 65 feet into the soil. When water is plentiful, mesquite grow rapidly and consume excessive amounts of water from shallow depths. During droughts mesquite use the tap root as a reserve, pumping water from far beneath the surface. Mesquite are also herd to kill. When the top of a tree is damaged or removed, new buds sprout causing a second growth that may be more of a problem than the original tree.

Mesquite flowers in the spring and summer, producing sweet tasting fruit pods which foraging animals eat and scatter in their dung. It has been estimated that a cow chip may contain as many as 1,000 viable mesquite seeds. The seeds are encased in hard coverings that permit them to remain dormant but viable for years.

Originally, much of Texas was covered by grasses, not brush. Mesquite began to spread with the advent of came grazing in the 1820s. In fact, the most heavily infested areas match the old Texas cattle drive trails that cover much of the state. Mesquite spread because: 1) It outcompetes grasses; 2) Cattle spread its seeds with their dung; and 3) Wildfires, which kill young mesquite trees, are much less common.

Some benefits of mesquite are that: 1) It supports wildlife such as deer, quail, javelins and other species; 2) It reduces erosion in areas with steep slopes; and 3) Charcoal, fuel, furniture, flour, teas and fermented drinks can be produced from its fiber and fruit.

THE TEXAS SCENARIO

In 1964, the USDA-Soil Conservation Service estimated that 88.5 million acres of Texas rangeland were infested with brush and that roughly half that land needed brush removal. Brush density is increasing and a 1987 report estimated that more than 105 million acres are now infested (Texas State Soil and Water Conservation Board, 1987). Although mesquite is the dominant brush species in most of Texas, juniper, live oak, huisache, cacti, saltcedar, sagebrush, and persimmon may also be consuming a At of water (the distribution of major brush species is shown in Figure 1).

Brush and range plants have been estimated to consume 38% of the rain that falls on Texas annually (37-70 million acre-feet of water). More than 16 million acres in Texas may be covered with more than 1,000 mesquite per acre (Sosebee, 1987).

The USDA-Soil Conservation Service (Table 1) estimates that as much as 10 million acre-feet (57% of all the water used in Texas in 1980 by the municipal, industrial, and agricultural sectors) could be made available annually through a comprehensive brush management program (Recenthin and Smith, 1967). This is a very rough estimate, based largely on data from other states using different range species. A 1983 report projected that brush control may produce an additional quarter-inch of runoff from each inch of rainfall above 15 inches annually (Hibbert, 1983). Preliminary data suggest that Texas' results may be less than that estimate (Figure 2).

There are a few Texas examples where brush management was implemented to increase water yields, and the results have been mixed. In 1979, 54,000 acres of saltcedar were removed from the Pecos River in west Texas and New Mexico and water yields did not significantly increase. A rancher near Walnut Springs cleared brush, planted grasses, and built terraces. The result was that "long dry and forgotten springs began to flow again. and "a usually dry creek bed became a flowing stream. (Recenthin and Smith, 1967). Similar results occurred on Rocky Creek near San Angelo, where increased flows of 525,000 gallons of water a year were attributed to brush control. The creek dried up in the 1930s but began flowing again in the 1960s after extensive brush removal along its 74,000-acre watershed.

HYDROLOGIC ISSUES

It's uncertain just how much water can be created through brush control. Data on the potential of brush management to increase water yields in Texas are scarce. Generally, the following conditions should be met if brush management will increase water supplies: 1) Rainfall should exceed 18 inches annually; 2) Brush that will be removed should be replaced with grasses that use less water; and 3) Replacement species should be shallow-rooted, deciduous, dormant or low in biomass.

Brush control impacts water yields as follows: 1) Groundwater initially receives most of the water produced, although surface water flows may be enhanced directly and indirectly (via groundwater recharge); 2) Rate of brush regrowth influences long-term yields; 3) Control methods that kill the roots and remove the whole plant are most successful, but follow-up treatments are needed; 4) Water yield projections generally overestimate results; and 5) Most increased yields have occurred in high rainfall years (McCarl and others, 1987).

If brush control creates additional water, it is vital to know when and how this water will be released. Increased surface water flows affect the amount of water available to water rights holders, augment the flow of rivers, and may worsen the possibility of flooding. Added recharge to groundwater areas could raise water tables and reestablish dormant springs. Simulation results from Arizona (Brown, 1986) indicate that: 1) Only had of the increased water supplies would be available for public consumption (the rest would be lost to evaporation, spillage and seepage); 2) The likelihood of flooding increased; and 3) Reservoir capacity would have to be increased.

TEXAS RANGE RESEARCH

Limited research has been conducted in Texas on the impact of brush control on water yields. One project involved brush removal by root plowing in the Edwards Aquifer and chemically killing mesquite in the Blacklands Prairie. Root plowing created numerous depressions in the soil which stored water, increased infiltration, and reduced runoff. Chemical treatments produced 10% more runoff, although more deep soil moisture was found beneath mesquite- dominated sites (Richardson, Burned and Bovey, 1979). Other research suggests that mesquite often result in greater subsurface soil moisture than grasses
(because of the action of the tap root and the buildup of organic matter), but produce lower total water yields.

Numerous studies are now under way in the Texas A&M University Range Science Department and The Texas Agricultural Experiment Station (the projects are partially funded by the Texas Water Development Board and the Edwards Underground Water District). Ongoing studies headed by Bob Knight are being conducted on rangelands near Uvalde and Throckmorton to evaluate the water use efficiency of grass and brush species, and to determine the impact of brush clearing on the water balance. Researchers are measuring evaporation, transpiration, soil water content, deep percolation and other data using Iysimeters (containers placed in the soil) at many of the sites. In a study near

Uvalde, nine small watersheds are being instrumented with streamflow gauges to measure surface water runoff from areas where brush has been cleared.

Computer modeling studies may help more accurately estimate water savings from brush control programs. A project led by Mary Leigh Wolfe of Texas A&M University's Agricultural Engineering Department is using field studies and hydrologic models to predict water yields from rangeland watersheds. The study will develop a mathematical model that will be tested using data from research sites at Throckmorton, Uvalde, Vernon and Alice. The model could be used to evaluate the impact of various levels of brush control on water yields.

Annual water budgets for shrubs and grasses were compared in another study at the LaCopita research area near Alice. Results indicate that the amount of water evaporated and transpired from both areas was similar. Grasses produced greater water yields and deep drainage than mesquite: there was almost an inch more of drainage below 6.5 feet in areas planted with grasses. Results suggest that brush management may increase water yields in years with above normal winter and spring rainfall (Weltz, 1987).

Another investigation examined water use and potential water yields from grassy and mesquite dominated areas near Throckmorton, using Iysimeters to measure plant water use, infiltration, and runoff. Three grasses that were tested (sideoats Drama, curlymesquite-buffalograss and Texas wintergrass) evaporated and transpired roughly the same amount of water as mesquite, but runoff was twice as great in mesquite-dominated areas (Franklin, 1987). Data suggest that the type of grass influences water yields: bunch-type midgrasses such as sideoats grama may have higher rates of infiltration, interception and evapotranspiration and less surface runoff than sod-forming grasses.

Researchers with the Range and Wildlife Management Department at Texas Tech University are investigating the amount of water mesquite consume, as it relates to soil moisture and rainfall. Ron Sosebee has been studying water usage of mesquite at Lubbock and Vernon. Preliminary results suggest that mesquite use as much water as is available during spring and summer months, providing limited recharge. The findings also indicate that mesquite first uses water from the upper sold profiles (near the surface), but that it depends on its deep root system for water when it is actively growing and during long droughts (Sosebee, 1976).

ENVIRONMENTAL CONCERNS

The principle environmental concerns include fears that chemicals used to kill brush may be harmful to humans and animals, and that all removal methods may lead to increased erosion and non-point source pollution. Techniques for removing brush include: 1) Mechanical methods such as root plowing, chaining, shredding, raking and stacking; 2) Chemical methods; 3) Prescribed burning; and 4) Biological controls such as goats and sheep. Most commonly recommended is an initial treatment with a herbicide followed by burning.

Research indicates that thinning heavily infested thickets, not complete removal, improves the habitat for deer, quail, and other wildlife. Revenues from hunting leases may increase after lands have been improved by brush control (Inglis, 1985). Wildlife habitat is enhanced when brush is removed in a mosaic or "checkerboard" pattern with areas receiving varying amounts of treatment. This provides the diversity of cover needed to support numerous game species. Clearing 70% of dense brush may increase water yields and still provide good game habitat.

Brush control programs may be accountable to federal and state water quality regulations, because they may initially increase erosion from newly cleared areas. Over time, however, brush removal should lead to decreased non-point source pollution. Many brush infested areas do not allow grass growth and the resulting bare ground is susceptible to erosion. As grasses are reestablished following brush removal, erosion should decrease significantly. Brush management may also pose a risk to the habitat of endangered cacti, birds such as the black capped vireo, and fish. Brush control programs may have to comply with regulations of the Endangered Species Act by replacing wildlife habitat or implementing techniques to protect and restore wildlife.

Water rights issues also arise when brush control programs create additional water supplies. If a sponsoring agency initiates a brush controlprogram, it may be difficult, K not impossible, to recover the conserved water under current Texas law. It is almost impossible to identify which water supplies were created specifically by brush control programs, making it difficult to establish ownership of the additional water that was created.

For example, in Texas, groundwater belongs to individual properly owners. This creates two dilemnas: 1) If a sponsoring agency increased groundwater flows, individuals (not the agency) would benefit; 2) If a rancher created additional groundwater supplies, he would lose the rights to the water if it moved beneath another property owner's land.

There is also a problem in benefitting from surface water flows created by brush management. Increased flows would first accrue to existing water rights holders. Even if a permit to divert the newly created surface water was approved by the Texas Water Commission, it would still be junior to all other rights in that river basin.

One exception is that individuals are able to capture diffused surface water (defined as water that is not part of a watercourse, but which evaporates, infiltrates into the ground or enters a body of surface water while running across a person's property). Once diffused surface water enters a waterway, it becomes surface water and is subject to state regulation. If the flow of diffused surface water is increased through brush management, it belongs to landowners as long as it is captured while it is on their property.

Western states have taken different postures toward marketing conserved water. In Oregon, legislation has been passed that rewards those who are efficient: in this system, persons who create new water supplies through conservation are entitled to market 75% of the water they produce. In Colorado, a large farm cleared brush near a stream and then petitioned for use of the water generated by the activity. The petition was denied and the conserved water was allocated to existing water rights holders.

ECONOMICS

For brush management to be successful in Texas, it must be economical for individual ranchers or sponsoring agencies. Issues involve: 1) The amount of water created; 2) The worth of that water to the general public, river authorities, cities or water districts; 3) Increased revenues landowners may receive from additional water supplies and hunting leases, and lower pumping costs; and 4) Improved grazing conditions.

Researchers with the Agricultural Economics Department of Texas A&M University are investigating economic returns from brush control programs. Scenarios were evaluated in which hypothetical brush management efforts resulted in an increased inch of annual water yield per acre on a South Texas range and 0.26 inches per acre on the Rolling Plains. Researchers Bruce McCarl and Ron Griffin considered impacts on water yields and other costs and benefits over a 12-year period in preparing the analyses. For South Texas ranchers, a 2.6% rate of return was projected n the rancher received no cost share funds. With a 40% cost share, the rate of return rose to 8.2%. For ranchers in the Rolling Plains, a 40% cost share would result in a 6.7% rate of return, but a 0% cost share would produce less than a 1% return (Griffin and McCarl, 1987).

Other current efforts include case studies of the San Antonio and Corpus Christi areas to develop data on the value of water produced by brush control, and to identify cities, water districts, and river authorities that may benefit from such activities. The analy- ses will compare the cost of water produced through brush control against development of other sources.

POLICY ALTERNATIVES

A number of possible policies may be implemented to spur brush management programs, including: 1) Low interest loans to ranchers (similar to the Texas Water Development Board's program to help farmers purchase efficient irrigation systems); 2) Cost sharing to support ranchers' efforts to remove brush; 3) Increased opportunities for marketing conserved water; 4) State regulations to specify maximum allowable levels of key brush plants; 5) Education programs to inform consumers; and 6) Research into hydrology, legal, economy and environmental issues to identify benefits of brush control programs.

One method to control brush would be to fund the state "Brush Control Bill. (S.B. 1083), which was passed in 1985. The bill calls for the State Soil and Water Conservation Board to: 1) Administer the Texas Brush Control Program; 2) Develop brush management strategies; and 3) Designate critical areas where brush problems are most severe. The Board will use the USDA- Soil Conservation Service's brush survey to identify areas where brush densities are highest. This information will be combined with data on water supplies, water demand, and potentials for increased yield to identify critical areas. The

Board hopes to sponsor a program to assist ranchers (probably with a cost-share of about 70%) in removing brush.

A list of critical areas has not yet been produced, but the Board has developed a list of reservoirs where brush control may enhance supplies (Figure 1). That list is based on the following criteria: 1) Reservoirs can accept additional flows; 2) Watersheds feeding the reservoirs are 500 square miles or less; 3) Opportunities for brush clearing exist above the reservoir; 4) Minimal stream diversions occur; 5) Runoff averages less than 5 inches per square mile; 6) Rainfall is 15-36 inches per year; 7) Channelization is not necessary; and 8) Brush infestation is greater than 20%.

SUMMARY

As Texas looks to secure additional water supplies to carry it into and beyond the year 2000, policy makers should consider a variety of options including brush control to meet future water needs. Replacing brush with grasses that use less water could supply Texas with large amounts of relatively inexpensive water. Brush control may also benefit the environment and improve grazing conditions.

The benefits of brush control to society in general must also be considered. There are obvious trade-offs: does society want to invest in subsidizing brush control programs? If so, how much are citizens willing to pay for such a program?

Before any statewide brush control program can be implemented, additional research must be performed to determine: 1) Prospects for developing new water supplies; 2) Economics of such programs; 3) Impacts of brush control on the environment; and 4) Institutional changes that could encourage conservation. Research may provide many of the answers ultimately used by policy makers to determine the feasibility of a comprehensive brush control program for improving Texas' water supplies.

REFERENCES

Brown, T.C., "The Value of Incremental Water Flow from Pinyon-Juniper Lands," Pinyon- Juniper Conference, Reno, NV,January 13-16,1986.

Franklin, Joe D., Hydrologic Aspects of Grass Dominated and Honey Mesquite Dominated Areas in the Rolling Plains of Texas, M.S. Thesis, Texas A&M University, College Station, TX, 1987.

Griffin, Ronald C., and Bruce A. McCarl, "Brushland Management for Water Yield: Should Policy Makers Encourage It?," Texas A&M University, College Station, TX, 1987.

Hibbert, A.R., "Water Yield Improvement Potential by Vegetation Management on Western Rangelands," Water Resources Bulletin, Minneapolis, MN, June, 1983.

Inglis, Jack M., "Wildlife Management and IBMS in Integrated Brush Management Systems for South Texas,. Integrated Brush Management Systems for South Texas: Development and Implementation (B1493), Texas Agricultural Experiment Station, College Station, TX, 1985.

McCarl, Bruce A., Ronald C. Griffin, Ronald A. Kaiser, Lansingh S. Freeman, Wilbert H. Blackburn, and Wayne R. Jordan, Brushland Management for Water Yield: Prospects for Texas (B-1569J, Texas Agricultural Experiment Station, College Station, TX,1987.

Recenthin, C.A., and H.N. Smith, Grassland Restoration, Part V, Effect on Water Yield and Supply, USDA Soil Conservation Service, Temple, TX, 1967.

Richardson, C.W., Earl Burnett, and R.W. Bovey, "Hydrologic. Effects of Brush Control on Texas Rangelands," Transactions of the ASAE, St. Joseph, Ml, 1979.

Sosebee, Ronald E.,UHydrology: The State of the Science of Evapotranspiration," Watershed Management on Range and Forest Lands, Utah Water Research Laboratory, Utah State University, Logan, UT, 1976.

Sosebee, Ronald E., 'Water Use by Mesquite in West Texas, Texas Tech University, Lubbock, TX,1987.

Texas State Brush Control Plan, Texas State Soil and Water Conservation Board, Temple, TX, 1987.

Weltz, Mark A., Observed and Estimated (ERHYM-II Model) Water Budgets for South Texas Rangelands, Ph.D. dissertation, Texas A&M University, College Station, TX, 1987.

FOR MORE INFORMATION

Carter, Meril G., "Effects of Drouth on Mesquite," Journal of Range Management, Denver, CO, September, 1964.

Easter, S. Joe and Ronald Sosebee, "Influence of Soil-Water Potential on the Water Relationships of Honey Mesquite, Journal of Range Management, Denver, CO, May, 1975.

Gilbert, Bill, "A Tree Too Tough to Kill,. Audubon, New York, NY, January,1985.

Knight, Robert W., W.H. Blackburn, and L.B. Merrill, "Influence of Oak Mattes on Watershed Characteristics, Edwards Plateau, Texas," Journal of Range Management, Denver, CO, 1984.

Knight, Robert W., W.H. Blackburn, and C.J. Scifres, "Infiltration Rates and Sediment Production Following Herbicide/Fire Brush Treatments," Journal of Range Management, Denver, CO, March, 1983.

Mesquite: Growth and Development, Management, Economics, Control and Uses (Research Monograph 1l Texas Agricultural Experiment Station, College Station, TX, 1973.

Pecos River Basin Water Salvage Project, U.S. Bureau of Reclamation, Amarillo, TX, 1979.