Chapter 16

Brush Management for Water Conservation

Charles R. Hart[1]

Introduction

Sixty percent of the land surface in Texas is rangeland. These rangelands comprise most of the states watershed. They often lie in the recharge zone of many aquifers in the state and provide the major contribution of surface runoff to rivers and streams. With drought conditions and the population of Texas steadily increasing, supplying water to diverse agricultural, industrial, and municipal uses has become of major concern. Brush has long been recognized as a "water thief" on Texas rangelands. Landscape-scale brush control programs have become increasingly popular for enhanced water production from rangelands. In 1985, Senate Bill 1083 implemented the State Agriculture Code that provide for "the selective control, removal, or reduction of noxious brush such as mesquite, pricklypear, saltcedar or other phreatophytes that consume water to a degree that is detrimental to water conservation" (Chapter 203, Brush Control). Since this time, major efforts have been made to implement State funded brush control programs, with mixed reviews. This paper will give a brief overview of brush control, specifically as a means to increase streamflow and thus increase water supplies in major reservoirs.

A comprehensive understanding of the linkages between brush and streamflow on rangelands must be realized to fully understand the cause and affect relationships. A recent article by Wilcox (2002) provides an excellent background and basis for understanding these processes, as well as a scientific based view point for the wide spread belief that Texas streamflows can be augmented through large scale brush control programs. The paper outlines four major effects of woody vegetation on the water cycle as being:

1) alters soil infiltration characteristics through root penetration and organic matter,
2) preserves soil moisture through shading and mulching,
3) alters subsurface flow paths through root activity that leads to the formation of micropores, and
4) draws off soil moisture through transpiration or interception.

[1] Assistant Professor and Extension Range Specialist
Texas Cooperative Extension
The Texas A&M University System

Obviously, we are mostly concerned with that amount of water drawn from the soil through transpiration or intercepted in the canopy of the shrubs and subsequently evaporated. One of the first questions becomes, then, how much water can be released by simply controlling brush on rangelands? The answer to this question is greatly influenced by not only the species of brush but also the habitat in which it grows. For the purpose of this review, we will look at three species that have gained increasing attention in Texas: mesquite, juniper, and saltcedar. Each of these species is not only unique in physical characteristics related to water use, but in the habitats they occupy as well.

While mesquite and juniper may grow over a broad range of habitat types, most control efforts have targeted upland or non-riparian rangeland. Saltcedar is generally restricted to riparian (along stream or river channels), sub-irrigated, or other areas receiving extra moisture such as low-lying areas or lake shorelines. The amount of water available to the plant (provided by both habitat and environmental conditions) will greatly affect the amount of water used by the plant.

Estimates of Water Use

Juniper

Western juniper (*Juniperus occidentalis*) was cited as using 4.09 acre feet of water per year in a study conducted in Oregon (Eddleman and Miller, 1991) as determined from measuring precipitation throughfall, stem flow, and interception along with transpirational water use. The study stated that this amount of use occurred during a year with good soil moisture with these numbers greatly reduced during dry years. They concluded that winter soil moisture recharge may be reduced over 50 percent by dense stands of western juniper.

Owens and Ansley (1997) reported daily water use by redberry juniper, ashe juniper, mesquite, and liveoak to range from 19.1 to 46.8 gallons/day/tree from research conducted at various sites in the Edwards Plateau (Figure 16-1). Using density estimates combined with a canopy model, the study also predicted water use by juniper in three pasture scenarios. The juniper population in an ungrazed pasture transpired an average of 1.4 acre feet per year, in a lightly browsed pasture transpired 0.97 acre feet per year, and in a heavily browsed pasture transpired 0.34 acre feet per year (Figure 16-2).

Mesquite

Water use by mesquite has shown similar variability. Using thermocouple psychrometry to measure soil and plant water potentials, Easter and Sosebee (1975) studied mesquite water use in irrigated and non-irrigated conditions. The trees growing under irrigated conditions produced two times more foliage and showed greater soil water depletion than the trees growing without irrigation. Their conclusions indicate that water loss via transpiration in honey mesquite was greater on bottomland and riparian sites than that from plants growing in shallow soils such as drier uplands.

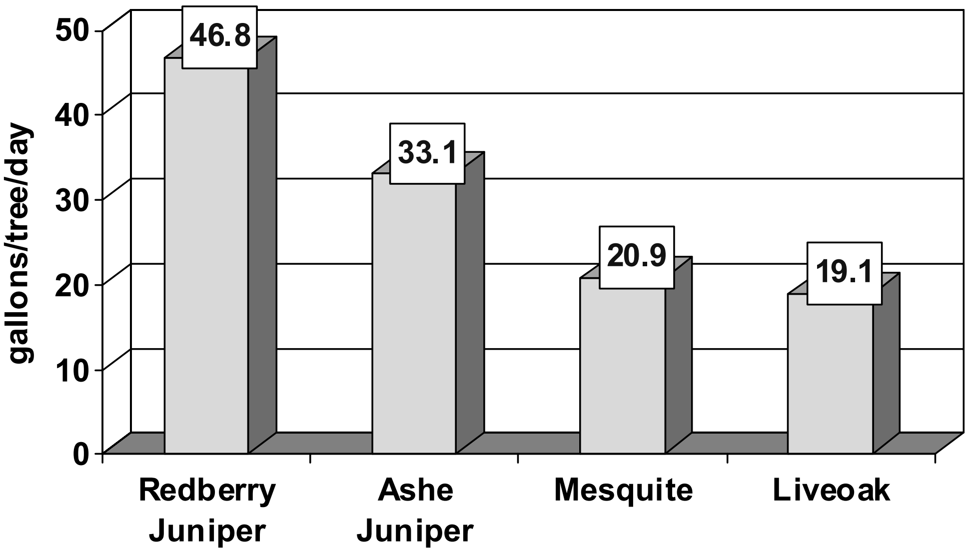

Figure 16-1: Estimated relative plant water use by four brush species in Texas (Owens and Ansley, 1997).

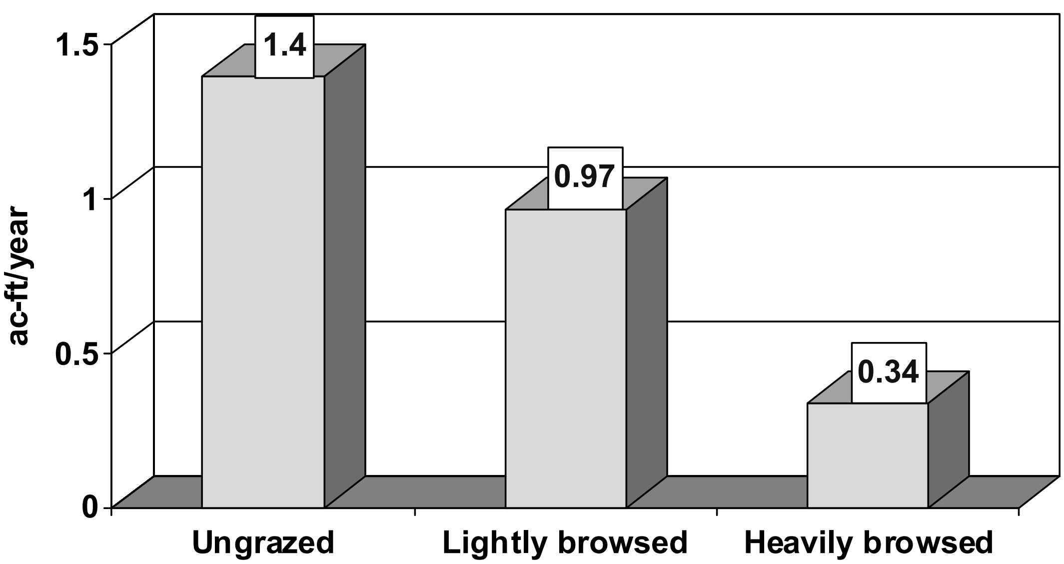

Figure 16-2: Juniper water use in Texas as influenced by grazing history based on preliminary models by Owens and Ansley (1997).

However, somewhat conflicting results were published by Cuomo and others (1992) measuring transpirational water use by honey mesquite in various habitats. Their study concluded that transpirational water use by honey mesquite was greater on upland sites than bottomland sites. They attributed the difference to higher soil moisture on the upland site, which was opposite than that of Easter and Sosebee (1975). Both papers agree that transpiration by honey mesquite was greater on sites that had more soil moisture.

Water use by honey mesquite is also affected by competition for moisture from other mesquite plants or surrounding vegetation. Response of honey mesquite water use to intraspecific competition was compared under low and high stand densities in a semi-arid environment (Ansley and others, 1998). A previous study (Ansley and others, 1991) found that severing of lateral roots reduced leaf transpiration by as much as 50 percent. This implies that on certain sites, availability of shallow water may be critical to mesquite physiological activity and that direct competition by neighboring plants should affect transpirational water use. Their study supported this hypothesis on the individual plant level as trees within a low density area (197 trees/acre) showed 2.5 to 4 times greater daily water loss than trees in a high density area (741 trees/acre) (Figure 16-3). However, daily water loss by mesquite at the stand level was similar between the low and high density areas (Figure 16-4). They concluded: “Since much of the soil water that was released by reducing mesquite density was used by the remaining mesquite or by increased grass growth, thinning mesquite stands may not increase off-site water yield on some sites.”

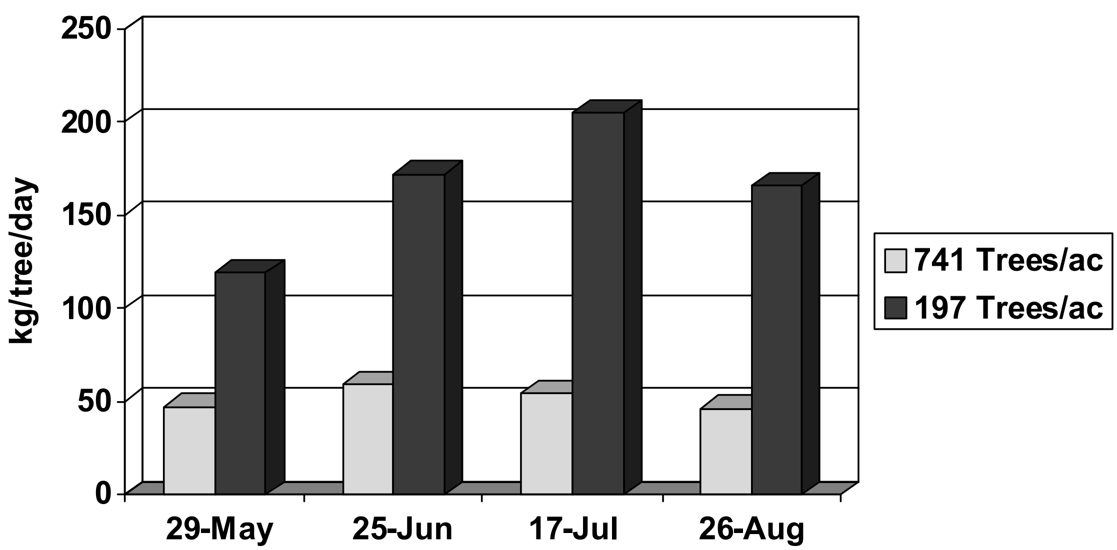

Figure 16-3: Effect of thinning on Daily transpiration of honey mesquite in the individual plant level (Ansley and others, 1998).

A water budget approach was used by Weltz and Blackburn (1995) to compare evapotranspiration rates between mesquite shrub clusters, grass interspace, and bareground. Annual evapotranspiration rates between shrub clusters and grass interspace were found to be similar, with both significantly higher than bareground. The bareground also produced significantly more surface runoff and deep drainage (>2m) than the shrub clusters or grass interspace. They found no deep drainage below the shrub clusters and very little (22mm) below the grass interspace over the 18 month study period. They concluded that no net change in the water budget would occur if shrub clusters were replaced with grasses in years with below average or normal precipitation.

Wilcox (2002) concluded: "Shrub control on mesquite dominated rangelands is unlikely to affect streamflow significantly for four reasons:

1) evaporative demand is high, and typical herbaceous replacement vegetation uses most of the available soil water;

2) soils on these sites are typically deep, effectively isolating the groundwater zone from the surface;

3) runoff is generated primarily as Horton overland flow; and

4) runoff is very flashy in nature, generated by flood producing events, overwhelming other factors.

He also concludes that there is some potential for increasing streamflow on juniper dominated rangeland based on two factors:

1) juniper canopies have a high capacity for interception of moisture, and

2) juniper are often found in regions where soils are shallow and parent materials are permeable.

Finally, Wilcox (2002) offers the following criteria for successful brush control yielding streamflow augmentation on uplands:

1) average annual precipitation must exceed 17 in. per year;

2) clearing high density stands has a greater effect than low density stands;

3) if runoff occurs primarily as Horton overland flow with occasional flood events, and base flow/groundwater recharge is insignificant, streamflow will be little influenced; and

4) there is a greater benefit from converting dense juniper to grass with little to no benefit from converting mesquite to grass.

Saltcedar

Saltcedar is well known for its ability to exploit groundwater from shallow sources. Estimates of water use by saltcedar have been reported in a number of papers over the last few decades. While the studies are too numerous to detail individually in this paper, general water use by saltcedar reported in the literature ranges from 0.75 to 2.6 meters (2.5 to 8.5 feet) per year (Figure 16-4). A review of this literature can be found in a thesis published by Texas A&M University (Hays, 2003). This recent research by Hays (2003) reports that transpirational water use by saltcedar along three major rivers in Texas during the 2000 growing season began in April and effectively ceased in October (Figure 16-5).

Evidence shows that water use by saltcedar is primarily influenced by stand density and age, depth to the water table, environmental conditions, and salinity of the water. Davenport and others (1982) estimated water use by saltcedar in sparse, medium, and dense stands as 2.2, 6.5, and 15.7 mm/year, respectively. Based on monitoring data from shallow groundwater monitoring wells in 2000, evapotranspirational water loss by saltcedar along the Colorado, Pecos, and Canadian rivers were quite different (Hays 2003). Saltcedar along a Colorado River site was characterized by dense young saltcedar growing in a flood plain near the river with a water table greater than 20 feet deep and evapotranspiration was estimated at 0.5 meters of water during the growing season. During the same season, dense mature saltcedar growing along the banks of the Pecos River in a 5-10 feet water table showed an evapotranspiration estimate of 2.3 meters. Comparatively, a dense, mature infestation of saltcedar and Russian olive along the Canadian River growing into a water table less than 3 feet deep evapotranspired 4.1

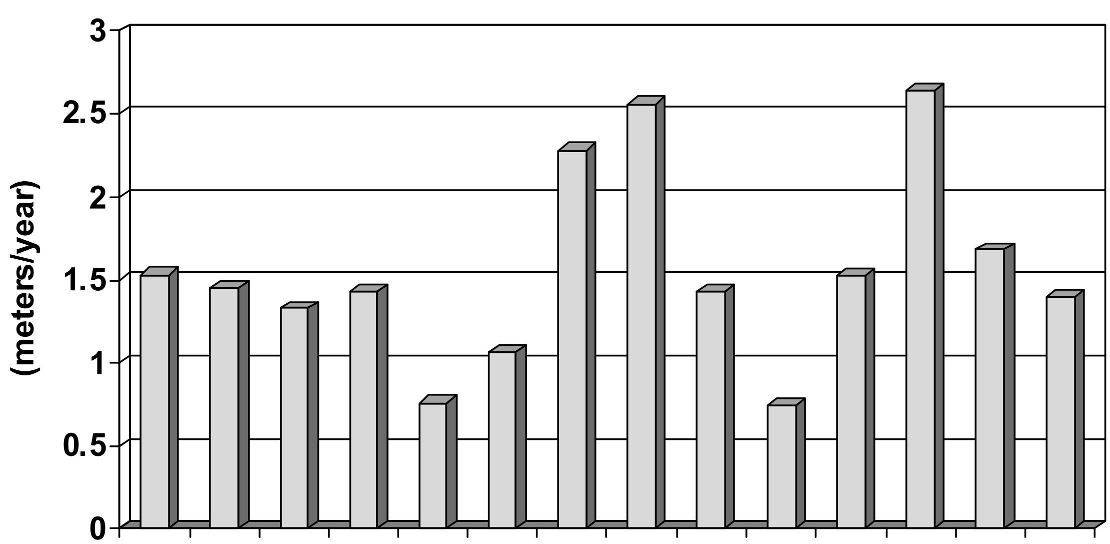

Figure 16-4: Representative water use by saltcedar from the literature as reviewed by Hays (2003).

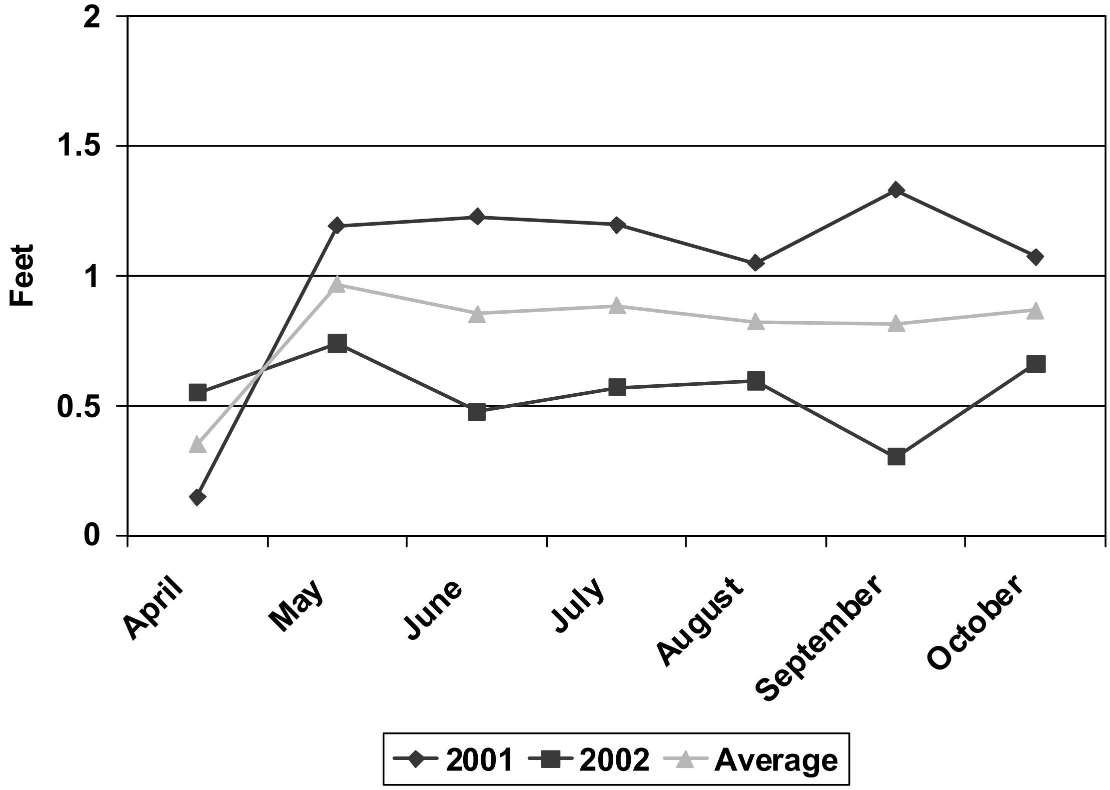

Figure 16-5: Monthly evapotranspiration water loss by saltcedar infested areas along three major rivers in Texas (Hays 2003).

meters during the year (Figure 16-6). Evapotranspirational water loss estimates total water loss including loss from evaporation and transpiration.

Estimates of water loss from the Pecos river site have shown considerable variability during the 2000 and 2001 growing season. During the 2000 growing season, normal flow was available in the river and water loss in saltcedar infested areas was estimated at 7.23 feet. At the same site during the 2001 growing season, river flow was reduced and the water table dropped 3 feet resulting in a water loss estimate of 3.9 feet (Figure 16-7). Saltcedar closer to the river also transpired more water than trees farther from the river.

In summary, the amount of water used by brush species varies considerably within habitats and environmental conditions. Figure 16-8 depicts relative and somewhat crude estimates of water use by various brush species. A detailed analysis of each situation must be undertaken before the effects of brush control on off-site water yield can be determined. Obviously, brush control on some habitat types will yield considerably more water than others. While it is a well-known fact that brush control is a water conservation practice on rangeland, it is not adequate to simply state that brush control in general will yield off-site water production.

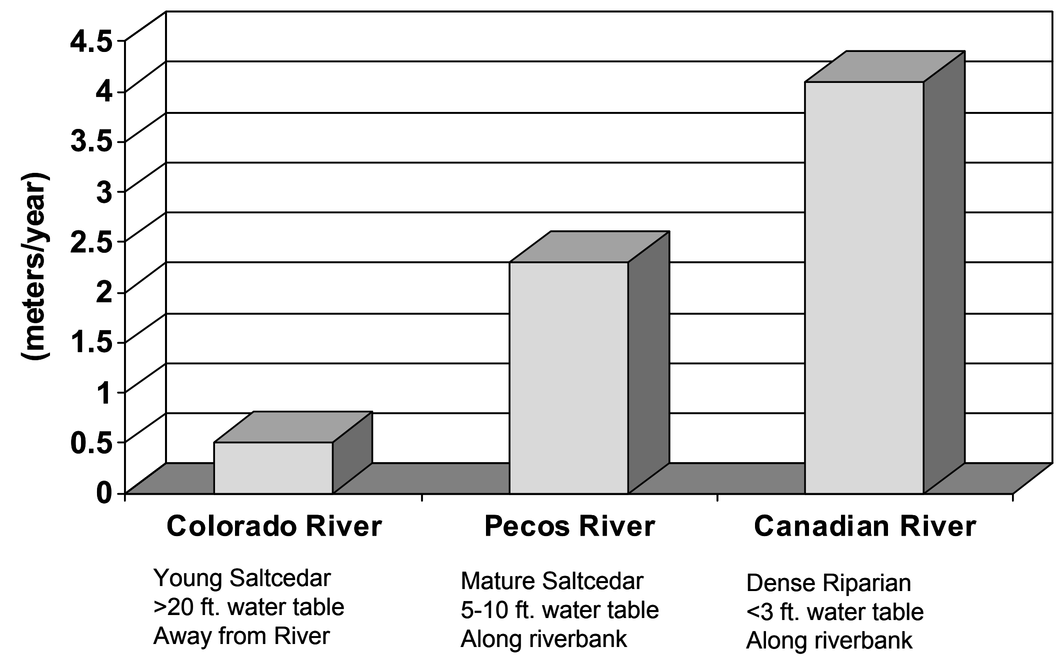

Figure 16-6: Evapotranspirational water loss from areas infested with saltcedar and associated plants on three major rivers in Texas, from 2000 well data (Hays, 2003).

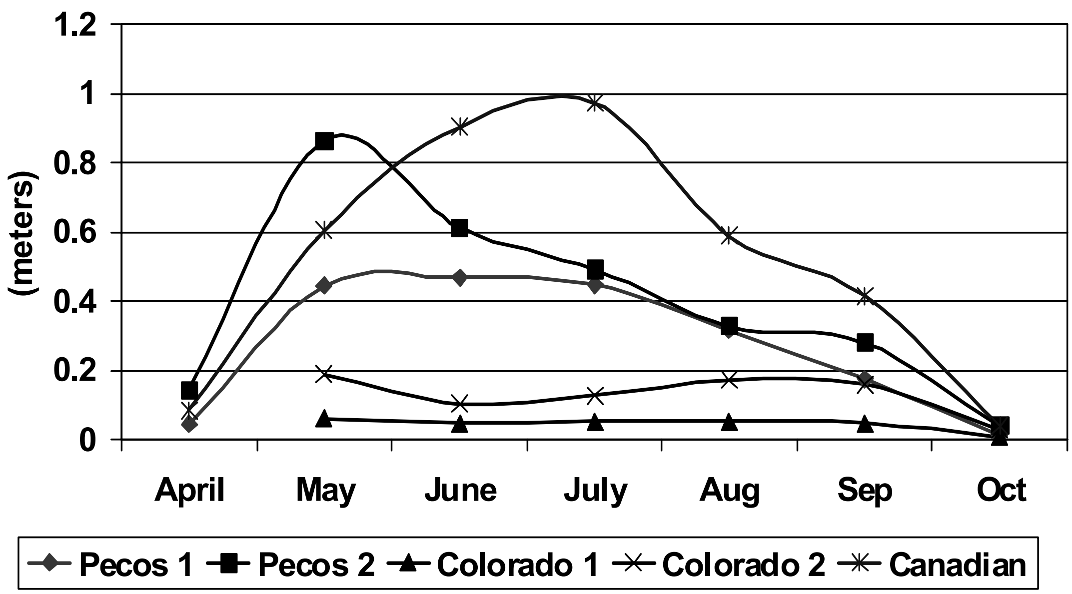

Figure 16-7: Estimated monthy evapotranspirational water use by saltcedar during the 2001 and 2002 growing seasons. During year 2001, water was released as normal from Red Bluff. Year 2002, no releases were made from Red Bluff. Water table dropped from an average of 3.9 to .07 feet.

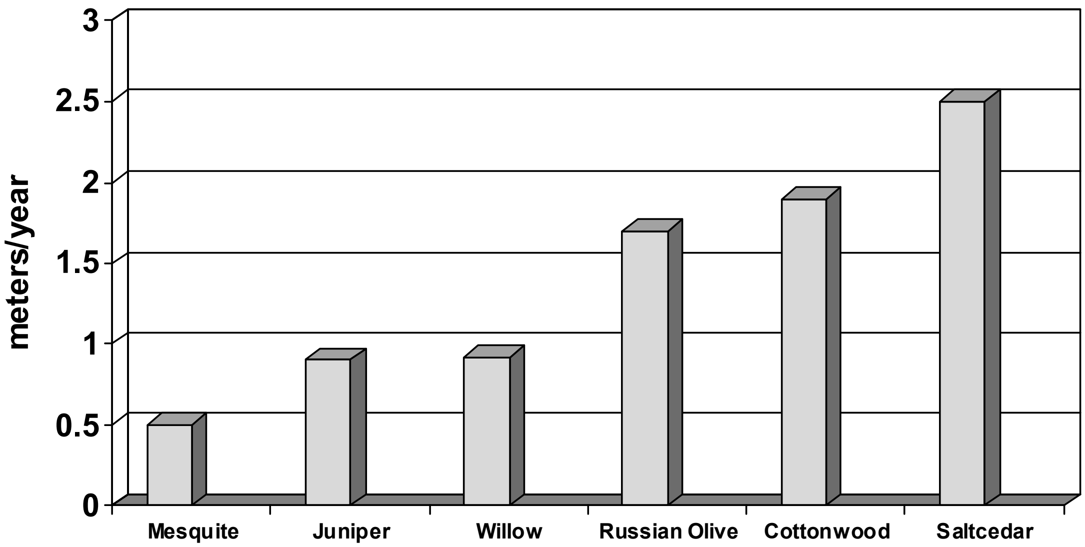

Figure 16-8: Representative examples of water use form the literature.

Economics of Brush Control for Streamflow Augmentation

Numerous feasibility studies for estimating cost of added water from mesquite and juniper control in Texas have been initiated through the guidance of the Texas State Soil and Water Conservation Board Brush Control Program. Studies have been conducted on various watersheds in Texas including the Frio River, Main Concho River, Pedernales River, Nueces River, Edwards Aquifer, Upper Colorado River, Canadian River, and Wichita. Average cost share to the State of Texas ranged from $16.41 to $111.37 per acre-foot of water released over a ten-year period (Table 16-1).

A further analysis of the Edwards Aquifer sub basins are presented for the Hondo, Medina, Sabinal, Seco, Upper Frio, and Upper Nueces. This study reported costs ranging from $26.68 per acre-foot on the Medina sub basin to $97.51 per acre-foot on the Upper Nueces sub basin. These values are adjusted for the delay in time availability over a ten-year period using a 6 percent discount rate (Table 16-2).

Average cost of saltcedar control in relation to treatment life on the Pecos River, Texas, was evaluated in a report published by the Center for Space Research (Faruqui, 2003). The analysis used actual treatment costs from the Pecos River Ecosystem Project over

Table 16-1: Average cost/ac-ft. of added water from control of mesquite and cedar on selected watersheds in Texas (TSSWCB).

Watershed	Acres Treated	Ac-ft/10 yrs	Cost/ac-ft*
Frio River	882,883	1,769,158	$36.95
Main Concho River	284,217	378,577	$42.32
Perdenales River	203,752	1,041,550	$16.41
Nueces River	3,152,211	5,369,726	$55.41
Edwards Aquifer	99,106	1,698,379	$47.19
Upper Colorado	2,075,282	1,113,124	$96.76
Canadian River	3,949,960	698,958	$111.37
Wichita	833,413	1,185,937	$36.59
Average			**$55.37**

*Adjusted for the delay in time of availability over 10 year period using 6 percent discount rate.

Table 16-2: Average cost/ac-ft. of added water from control of mesquite and cedar on the sub-basins of the Edwards Aquifer watershed (TSSWCB).

Watershed	Acres Treated	Ac-ft/10 yrs	Cost/ac-ft*
Frio River	882,883	1,769,158	$36.95
Main Concho River	284,217	378,577	$42.32
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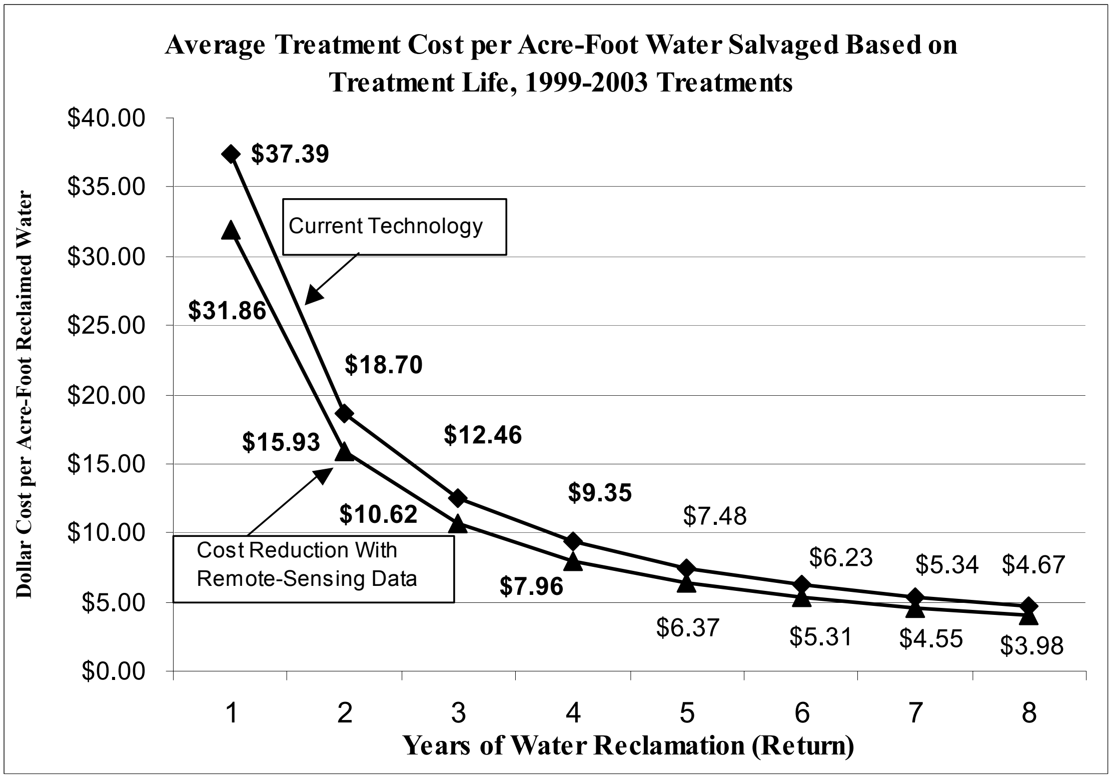

Figure 16-9: Average treatment cost from saltcedar control on the Pecos River based on treatment life. Data reported by Faruqui, Center for Space Research in Cooperation with TCE and TDA, 2003. Data based on reclaiming 5 ac-ft of water per acre of saltcedar treated.

four treatment years (1999-2002) and an annual salvage estimate of 5 acre-feet of salvaged water for every acre of saltcedar treated. It considered all costs of treatment including pre-treatment preparations, application, and herbicide costs. Herbicide application costs ranged from $180 to $190 per acre. If water salvage was realized for only one growing season following saltcedar control, cost of salvaged water was estimated at $37.39 per acre-foot (Figure 16-9). Annual estimates were made for treatment life up to 8 years. If treatment life extended to eight years, cost of water salvaged was estimated at $4.67 per acre-foot. To date, a treatment life of four years has been realized resulting in a cost of $9.35 per acre-foot of water salvaged.

As stated earlier, there is no doubt that brush control is a viable water conservation practice for Texas rangelands. There is some question as to where and when brush control will produce economically viable increases in streamflow augmentation to reservoirs. Due to the relative high consumptive use of water by saltcedar, and the fact that it generally grows in close proximity to flowing, standing, or shallow underground water, saltcedar control should be considered as a practice for increasing streamflow. Control of upland species such as mesquite and juniper may increase streamflow to reservoirs in certain situations. Regardless of the species being considered, brush control for streamflow augmentation should target areas that show the greatest economical potential for increasing water yields to reservoirs. With proper planning and implementation, brush control can and should be considered as a viable option for helping to meet the water supply demands for future Texans.

References

Ansley, R. J., Trevino, B. A., and Jacoby, P. W., 1998, Intraspecific competition in honey mesquite: Leaf and whole plant responses: Journal of Range Management, v. 51, p. 345.

Cuomo, C. J., Ansley, R. J., Jacoby, P. W., and Sosebee, R B., 1992, Honey mesquite transpiration along a vertical site gradient: Journal of Range Management, v. 45, p. 334.

Easter, J. S., and Sosebee, R. E., 1975, Influence of soil-water potential on the water relationships of honey mesquite: Journal of Range Management, v. 28, p. 230.

Eddleman, L. E., and Miller, P. M., 1991, Potential impacts of western juiper on the hydrologic cycle: Symposium on ecology and management of riparian shrub communities, Sun Valley, ID, May 29-31.

Faruqui, S. J., 2003, A cost-benefit analysis for utilizing remote-sensing data in herbicidal treatment of salt cedar along river systems: Center for Space Research Report.

Hays, B., 2003, Water use by saltcedar (Tamarix spp.) and associated vegetation on the Canadian, Colorado and Pecos Rivers in Texas: M.S. Thesis, Texas A & M University. College Station, Texas, 116 p.

Owens, K., and Ansley, J., 1997, Ecophysiology and growth of ashe and redberry juniper: Texas Agricultural Experiment Station Technical Report 97-1.

Weltz, M. A., and Blackburn, W. H., 1995, Water budget for South Texas rangelands: Journal of Range Management, v.48, p. 45.

Wilcox, B. P., 2002, Shrub control and streamflow on rangelands: A process based viewpoint: Journal of Range Management, v. 55, p. 318-326.