STATE WATER SUPPLY ENHANCEMENT PLAN

JULY 2014

TEXAS STATE SOIL AND WATER CONSERVATION BOARD

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The State of Texas' comprehensive strategy for managing brush in all areas of the state where brush is contributing to a substantial water conservation problem.

From the Era of the Dust Bowl to the Present
Commemorating 75 Years of Soil and Water Conservation in Texas

TEXAS STATE SOIL AND WATER CONSERVATION BOARD

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Over the past two and a half years TSSWCB staff have worked with a Stakeholder Committee, a Science Advisory Committee, and others to discuss how best to implement changes to the WSEP that the Legislature requested. Both Committees have worked hard to ensure that the best available science is being used by the TSSWCB to direct precious State funds to those areas where we can best realize the positive impacts of brush control to enhance public water supplies. The recommendations by these Committees have guided the decisions the TSSWCB has made to implement the Legislative directives for the WSEP. The TSSWCB extends a special thanks and recognition to all those who contributed to the development of this *State Water Supply Enhancement Plan*.

Stakeholder Committee

Robert Mace, TWDB
Ken Rainwater, TTU
Jule Richmond, ATSWCDs
Jason Skaggs, TSCRA
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Science Advisory Committee

Ryan Banta, USGS (alternate)
Daren Harmel, USDA-ARS
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George Ozuna, USGS
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Other contributions and input from: Tom Arsuffi, TTU; Clyde Bohmfalk, TCEQ (deceased); Johnathan Bumgarner, USGS; David Dunn, HDR; Richard Eyster, TDA (retired); Terry McLendon, TTU; Brian Perkins, HDR; Steve Raabe, SARA; Doug Shaw, TWDB; and, Cameron Turner, TWDB.

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Abbreviations, Acronyms, and Initialisms

AgriLife Extension	Texas A&M AgriLife Extension Service
AgriLife Research	Texas A&M AgriLife Research
ARS	USDA Agricultural Research Service
ATSWCDs	Association of Texas Soil and Water Conservation Districts
BCP	Texas Brush Control Program
BMP	best management practice
BRA	Brazos River Authority
CRMWA	Canadian River Municipal Water Authority
CWA	federal Clean Water Act
EAA	Edwards Aquifer Authority
EDYS	Ecological Dynamics Simulation model
EQIP	USDA-NRCS Environmental Quality Incentives Program
ESRI	Environmental Systems Research Institute, Inc.
ET	evapotranspiration
FOTG	USDA-NRCS Field Office Technical Guide
GBRA	Guadalupe-Blanco River Authority
GCD	groundwater conservation district
gpd	gallons per day
LBB	Legislative Budget Board
LCRA	Lower Colorado River Authority
NRA	Nueces River Authority
NRCS	USDA Natural Resources Conservation Service
NRI	USDA-NRCS National Resources Inventory
PWS	public water supply
RFP	request for proposals
RRA	Red River Authority of Texas
RWPG	regional water planning group
SARA	San Antonio River Authority
SPUR	Simulating Production and Utilization of Rangeland model
SWAT	Soil and Water Assessment Tool
SWCD	soil and water conservation district
TAC	Texas Administrative Code
TAGD	Texas Alliance of Groundwater Districts
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TFS	Texas A&M Forest Service
TGPC	Texas Groundwater Protection Committee
TIAER	Texas Institute for Applied Environmental Research at Tarleton State University
TISCC	Texas Invasive Species Coordinating Committee
TPWD	Texas Parks and Wildlife Department
TSCRA	Texas and Southwestern Cattle Raisers Association

TSSWCB	Texas State Soil and Water Conservation Board
TTU	Texas Tech University
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute, a unit of AgriLife Research
UCRA	Upper Colorado River Authority
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMS	water management strategy in the State Water Plan
WSEP	Water Supply Enhancement Program
WUG	water user group

Chapter 1 Introduction to WSEP and TSSWCB

Scarcity and competition for water have made sound water planning and management increasingly important. The demand for water in Texas is expected to increase by about 22%, to a demand of nearly 22M ac-ft in 2060; while existing water supplies are projected to decrease by about 10%, to just over 15M ac-ft. With Texas' population expected to grow by 82% in the next 50 years, the availability of water supplies is essential for not only the Texans of today but also for those of tomorrow. (TWDB 2012)

Noxious brush, detrimental to water conservation, has invaded millions of acres of rangeland and riparian areas in Texas, reducing or eliminating stream flow and aquifer recharge through interception of rainfall and increased ET. Brush control has the potential to enhance water yield, improve soil conservation, protect water quality, reduce hazardous fuels to mitigate wildfire, and manage invasive species.

In order to help meet the State's critical water conservation needs and ensure availability of public water supplies, in 2011 the 82nd Texas Legislature established the WSEP administered by the TSSWCB, with the purpose of increasing available surface and ground water supplies through the targeted control of brush species that are detrimental to water conservation (e.g., juniper, mesquite, saltcedar).

The TSSWCB collaborates with SWCDs, and other local, regional, state, and federal agencies to identify watersheds across the state where it is feasible to implement brush control in order to enhance public water supplies. The TSSWCB uses a competitive grant process to rank feasible projects and allocate WSEP grant funds, giving priority to projects that balance the most critical water conservation need of municipal WUGs with the highest projected water yield from brush control.

In watersheds where WSEP grant funds have been allocated, the TSSWCB works through SWCDs to deliver technical assistance to landowners in order to implement brush control activities for water supply enhancement. A 10-year resource management plan is developed for each property enrolled in the WSEP which describes the brush control activities to be implemented, follow-up treatment requirements, and brush density to be maintained after treatment. Cost-share assistance is provided through the WSEP to landowners implementing brush control activities on eligible acres.

More information on the WSEP is available at http://www.tsswcb.texas.gov/brushcontrol/.

Section 1.1 Texas Conservation Partnership

The TSSWCB, established in 1939, works in partnership with the State's 216 local SWCDs to encourage the wise and productive use of the State's natural resources in a manner that promotes a clean, healthy environment and strong economic growth. The TSSWCB

- administers Texas' soil and water conservation law;
- delivers coordinated natural resource conservation programs through the State's 216 SWCDs;
- is the lead agency for planning, implementing, and managing programs for preventing and abating agricultural and silvicultural (forestry-related) nonpoint sources of water pollution;
- administers the WSEP to increase available surface and ground water through the targeted control of water-depleting brush;
- works to ensure the State's network of 2,000 flood control dams are protecting lives and property; and,
- facilitates the Texas Invasive Species Coordinating Committee.

The TSSWCB is governed by a seven-member State Board composed of two Governor-appointed Members and five Members elected from across Texas by the directors of the State's 216 SWCDs. All seven Members of the State Board must be landowners actively engaged in farming or ranching.

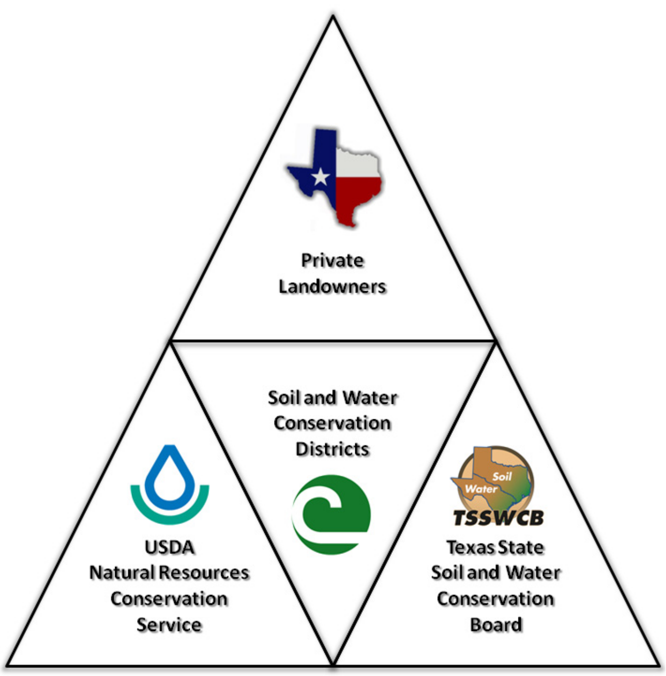

Figure 1.1.1 Texas Conservation Partnership

SWCDs are independent political subdivisions of state government, like a county or school district. The first SWCDs in Texas were organized in 1940 in response to the widespread agricultural and ecological devastation of the Dust Bowl of the 1930s. There are 216 SWCDs organized across the state, covering 100% of lands in the state. Each SWCD is governed by five directors elected by landowners within the SWCD boundaries.

As illustrated in Figure 1.1.1, SWCDs serve as the State's primary conservation delivery system through which technical assistance and financial incentives for natural resource conservation programs are channeled to agricultural producers and rural landowners. SWCDs work to combat soil and water erosion, protect water quality, and enhance public water supplies across the state by giving farmers and ranchers the opportunity to solve local conservation challenges. SWCDs instill in landowners and citizens a stewardship ethic and individual responsibility for soil and water conservation.

Many of the TSSWCB's statewide programs, such as the WSEP, are administratively coordinated through the efforts of local SWCDs; TSSWCB relies on the infrastructure, or conservation delivery system, of the 216 SWCDs. Additionally, SWCDs assist federal agencies in establishing resource conservation priorities for federal Farm Bill and CWA programs based on locally-specific knowledge of natural resource concerns. SWCDs have organized themselves into a tax-exempt, non-profit organization, the Association of Texas Soil and Water Conservation Districts and into 13 Area Associations. The conservation delivery system that SWCDs present for the State is one of the most efficient and effective mechanisms for conducting natural resource conservation programs (e.g., brush control for water supply enhancement).

Section 1.2 History of the WSEP

In 1985, the 69th Texas Legislature created the Texas Brush Control Program (SB1083) and designated the TSSWCB as the agency responsible for administering the Program. For the next 14 fiscal years (1986-1999), the BCP was unfunded, until 1999 when the 76th Legislature appropriated funds to begin implementing the BCP. TSSWCB was appropriated varying amounts of funding for 12 fiscal years (2000-2011) to carry-out the BCP. The BCP's original purpose was to incentivize brush control on private lands for the purpose of enhancing water availability for all needs.

Notable actions by the Legislature with respect to the BCP include, for the 2002-2003 biennium, the 77th Legislature directed proceeds of Texas Agricultural Water Conservation Bonds be transferred from the TWDB as a grant of $15M to the TSSWCB to be used for brush control cost-share projects and as a grant of $1M to the TDA to be used for the Pecos River Ecosystem Project for saltcedar control. Additionally, the 80th Legislature directed the TCEQ to submit a report to the LBB and the Governor by the end of FY2008 providing the following information on brush control activities being conducted by the TSSWCB: evaluation of the current monitoring programs at the treated sites; identification of proper monitoring approaches where upgrades are needed; and estimation of water enhancement in areas of the state that are characterized by saltcedar, juniper, and mesquite. Further, many of the BCP's project areas were specifically identified in Appropriation Riders. For example, Riders directed over $16M to be used for a pilot brush control project in the North Concho River watershed.

Table 1.2.1 Biennial Appropriations for the BCP and the WSEP

Legislature	FYs	Program	Amount	Source
76	2000-2001	BCP	$ 9,163,189	General Revenue
77	2002-2003	BCP	$ 24,163,189	General Revenue & Agricultural Water Conservation Bond
78	2004-2005	BCP	$ 3,722,599	General Revenue
79	2006-2007	BCP	$ 3,690,185	General Revenue
80	2008-2009	BCP	$ 4,417,853	General Revenue
81	2010-2011	BCP	$ 9,087,282	General Revenue
82	2012-2013	WSEP	$ 4,270,826	General Revenue
83	2014-2015	WSEP	$ 4,270,826	General Revenue
			$ 62,785,949	

SUNSET REVIEW

The Texas Sunset Advisory Commission identifies and eliminates waste, duplication, and inefficiency in government agencies. The 12-member Commission reviews the policies and programs of more than 130 government agencies every 12 years. The Commission questions the need for each agency, looks for potential duplication of other public services or programs, and considers new and innovative changes to improve each agency's operations and activities. The Commission recommends actions on each agency under review to the full Legislature.

The Sunset Advisory Commission conducted a review of the TSSWCB in 2009-2011. During this process, the Sunset Advisory Commission adopted recommendations to address several issues identified with TSSWCB programs. One issue concluded that the then current framework of the BCP was not effective for meeting the State's critical water conservation needs. As a result of the Sunset Commission's recommendations for improving the program, in 2011, the 82nd Legislature enacted HB1808 which delineated significant changes to TSSWCB's programs, including the elimination of the BCP effective September 2011. HB1808 established a new program for the agency, the WSEP, with the purpose of increasing available surface and ground water supplies through the targeted control of brush species detrimental to water conservation. TSSWCB has been appropriated funds for four fiscal years (2012-2015) to carry-out this new WSEP.

SUNSET IMPLEMENTATION

HB1808 intensified the agency's focus on enhancing ground and surface water supplies by requiring the TSSWCB to establish goals for the WSEP which must describe the intended use of a PWS enhanced by the WSEP and the populations that the WSEP will target. The legislation also required the TSSWCB to develop a system to prioritize project proposals for each funding cycle, giving priority to projects that balance the most critical water conservation need of municipal WUGs with the highest projected water yield from brush control.

In order to provide recommendations to the agency and guide the decisions of the State Board in implementing provisions of HB1808, the TSSWCB established a Stakeholder Committee of Program Beneficiaries and a Science Advisory Committee of technical experts.

The Stakeholder Committee of Program Beneficiaries provided recommendations for WSEP goals and the proposal ranking process. The Stakeholder Committee is comprised of:

- Robert Mace, TWDB
- Ken Rainwater, TTU
- Jule Richmond, ATSWCDs
- Jason Skaggs, TSCRA
- vacant, TCEQ (Clyde Bohmfalk formerly held this position)

The Science Advisory Committee of technical experts provided recommendations regarding feasibility studies and the method for prioritizing acreage for brush control. The Science Advisory Committee is comprised of:

- Ryan Banta, USGS (alternate) (Johnathan Bumgarner formerly held this position)
- Daren Harmel, USDA-ARS
- Larry Hauck, TIAER
- George Ozuna, USGS
- Ken Rainwater, TTU
- Ruben Solis, TWDB
- David Villarreal, TDA
- Yujuin Yang, TWDB (alternate)

The TSSWCB adopted comprehensive rules (31 TAC Chapter 517, Subchapter B) in March 2012 (effective April 2012) addressing many aspects of the Sunset legislation, transitioning the rules from the BCP to the WSEP. Further amendments to the rules were adopted by the TSSWCB in July 2014 (effective September 8, 2014) to continue implementing provisions of HB1808 and ensure consistency with programmatic policies and documents.

On May 15, 2014, the State Board approved a revised *Policy on Allocation of Grant Funds for the WSEP*. This policy was originally approved on March 6, 2013 and revised on July 18, 2013. This policy describes the WSEP's purpose and goals, the competitive grant process and proposal ranking criteria, factors that must be considered in a feasibility study, the geospatial analysis methodology for prioritizing acreage for brush control, and how the agency will allocate funding.

On May 15, 2014, the State Board approved a revised *Policy on Brush Control Feasibility Studies for the WSEP*. This policy was originally approved on July 18, 2013. This policy describes the requirements for computer modeling for water yield predictions in feasibility studies and the process to review applications for funding to conduct new feasibility studies.

On May 15, 2014, the State Board approved a *Policy on Funding Technical Assistance for Brush Control through SWCDs for the WSEP*. In order to maximize the effective and efficient use of WSEP grant funds, this policy describes the options SWCDs have for providing technical assistance to landowners and administering the cost-share program. This policy provides a foundation for the TSSWCB in considering the administrative capacities of an entity that will manage a water supply enhancement project.

These three *Policies* were incorporated into the WSEP rules (31 TAC Chapter 517, Subchapter B) and this *Plan*.

Section 1.3 Purpose of State Water Supply Enhancement Plan

Scarcity and competition for water have made sound water planning and management increasingly important. The demand for water in Texas is expected to increase by about 22%, to a demand of nearly 22M ac-ft in 2060; while existing water supplies are projected to decrease by about 10%, to just over 15M ac-ft. With Texas' population expected to grow by 82% in the next 50 years, the availability of water supplies is essential for not only the Texans of today but also for those of tomorrow. (TWDB 2012)

In fall 2008, Texas citizens were surveyed about their perceptions and attitudes related to water resources. Surprisingly, more than 44% of all respondents believe water quantity issues are definitely not or probably not a problem where they live. A slightly larger number (47.9%) responded that water quantity is definitely or probably a concern. Respondents also were asked to evaluate the likelihood of their area having adequate water to meet its needs 10 years from now. Twenty percent (20%) of respondents thought there was a high chance of their area having adequate water resources, while about 41.3% thought there was only a medium chance, and 30.3% thought there was a low chance that their area will have adequate water. (Boellstorff et al. 2010)

In another survey of Texans conducted in spring 2013, water issues ranked fifth among a list of ten major issues facing the country. While most respondents believed that short-term changes in annual rainfall are a major cause of water shortages, they also cited overuse and inadequate management of water resources, and increased demand as additional important factors affecting drought. Respondents also believed that over the next five years diminishing water resources will result in more conflicts over water use, higher water costs, greater fire danger, increased food prices, a loss of recreational opportunities, and damage to plant and animal species. (Stoutenborough and Vedlitz 2013)

The demand for water in Texas is expected to increase by about 22%, from about 18.01M ac-ft per year in 2010 to a demand of about 21.95M ac-ft in 2060. Existing water supplies are projected to decrease by about 10%, from about 16.98M ac-ft in 2010 to about 15.27M ac-ft in 2060. If no action is taken to implement the *State Water Plan*, over 50% of the state's population in 2060 would face a water need of at least 45% of their projected demand during a repeat of drought conditions (TWDB 2012).

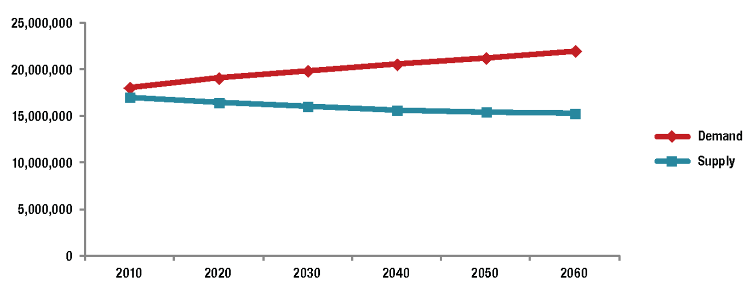

Figure 1.3.1 Projected Water Demand and Existing Supplies (ac-ft per yr). (TWDB 2012)

Noxious brush, detrimental to water conservation, has invaded millions of acres of rangeland and riparian areas in Texas, reducing or eliminating stream flow and aquifer recharge through interception of rainfall and increased ET. The USDA-NRCS estimated that as much as 10M ac-ft of water could be made available annually through a comprehensive brush management program (Rechenthin and Smith 1967). Possible benefits of brush control include yield increases to State surface water supplies, recharge of groundwater aquifers, and spring flow enhancement. Economic benefits of the use of brush control to enhance water yield have been estimated by several feasibility studies conducted for the TSSWCB and various partnering entities. Brush control is an economically feasible option for water yield enhancement in a number of the watersheds studied. (UCRA 1999; other Brush Control Feasibility Studies)

Water needs and potential water yields that may be captured and used for public benefit are the primary considerations for determining the location of publicly funded (i.e., cost-share) brush control projects. 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 landowner participation in a brush control project will primarily depend on the landowner's expected economic consequences resulting from participation. In order to achieve restoration of ecosystem functions (i.e., enhanced water yield from brush control), solutions must be socially accepted, economically bearable, and based on environmental goals (Figure 1.3.2).

Figure 1.3.2 Social, Economic, and Environmental Considerations to Achieve Ecosystem Restoration and Enhanced Water Yield

Therefore, in order to help meet the State's critical water conservation needs and ensure availability of water supplies, the WSEP administered by the TSSWCB will increase available surface and ground water supplies through the targeted control of brush species that are detrimental to water conservation.

In accordance with Texas Agriculture Code §203.051, the TSSWCB must prepare and adopt the *State Water Supply Enhancement Plan*. The *State Water Supply Enhancement Plan* serves as the State's comprehensive strategy for managing brush in all areas of the state where brush is contributing to a substantial water conservation problem. The *State Water Supply Enhancement Plan* also serves as the programmatic guidance for the TSSWCB WSEP, established under Chapter 203 of the Agriculture Code.

The statutorily-defined (Agriculture Code §§203.001-203.002) purpose of the WSEP is to increase available surface and ground water through:

- the selective control, removal, or reduction of noxious brush species, such as juniper, mesquite, saltcedar, or other phreatophytes, that consume water to a degree that is detrimental to water conservation; and,
- the revegetation of land on which this noxious brush has been controlled, removed, or reduced.

The *State Water Supply Enhancement Plan* must document the goals, processes, and results the TSSWCB has established for the WSEP under Agriculture Code §201.029, including:

- a goal describing the intended use of a PWS enhanced or conserved by the Program, such as agricultural purposes or drinking water purposes; and,
- a goal describing the populations that the WSEP will target.

As the programmatic guidance for the WSEP, the *State Water Supply Enhancement Plan* also discusses the competitive grant process, the proposal ranking criteria, factors that must be considered in a feasibility study, the geospatial analysis methodology for prioritizing acreage for brush control, how the agency will allocate funding, priority watersheds across the state for water supply enhancement and brush control, and how success for the WSEP will be assessed and how overall water yield will be projected.

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Chapter 2 Brush Management and Water Yield

Section 2.1 Encroachment of Brush Across the State

Within the past 160 years, rangeland vegetation has undergone a large-scale conversion from grasslands and savannas to woodlands and shrubland (Scholes and Archer 1997). This shift is termed brush encroachment because the brush species that have always existed within the landscape have increased in extent and/or density (Arrington et al. 2002). Numerous written descriptions by early European settlers, summarized by Smeins et al. (1997), characterize most of Texas rangelands as grassland or open savanna. Prior to European settlement, grazing pressure tended to be light and/or periodic, thus allowing a robust stand of grass to establish. Most tree seeds deposited in a healthy grassland die soon after they germinate because they are unable to compete with the established grass for water and light. The few tree seedlings that are able to survive the competition with grass tend to perish in wildfires which periodically occur in “natural” rangelands. Thus, with fire and light grazing pressure, grasslands and savannas are stable and sustainable ecosystems characteristic of many Texas rangelands.

European settlement of rangelands altered the grazing and fire characteristics which had previously enabled grasslands to dominate the landscape. Continuous, often heavy, livestock grazing pressure reduced the ability of grasses to suppress tree seedling establishment. Furthermore, some woody species (e.g., juniper and mesquite) have noxious chemicals in their leaves, resulting in livestock tending to avoid browsing the tree seedlings while repeatedly grazing the adjacent, palatable grasses. This selective grazing behavior gives unpalatable tree seedlings a competitive advantage over grasses. European settlers tended to aggressively suppress fires, a task made easier because continuous, heavy grazing pressure removed the fuel needed to carry a fire. Removal of fire and added heavy grazing pressure created an environment that favored increased dominance of shrubs and trees in what had previously been grasslands or savannas. This pattern of vegetation change coincides with European settlement of rangelands throughout the world (Archer 1994). Overgrazing, range fire suppression, and droughts caused a gradual ecological change that promoted the spread of noxious brush (RRA 2002; Arrington et al. 2002; Van Auken 2000).

Large increases in woody cover can adversely affect ranching operations by increasing the costs of management and decreasing the livestock carrying capacity. Therefore, ranchers have a vested interest in controlling brush. For example, analysis of the 80 mi^2 Cusenbary Draw watershed near Sonora revealed that investments in brush control by ranchers were able to keep overall brush cover within the watershed between 22-24% between 1955 and 1990 (Redeker et al. 1998). Some of the pastures within the watershed did not have any brush control applied. Brush cover on those sites increased to 37% over the same period. This illustrates the increase in shrub cover over a 35-year period that is possible in the area without a proactive policy of brush control.

Ranches throughout several regions of Texas are increasingly being subdivided into smaller parcels that are used mainly for recreation (Rowan and White 1994).

A Texas survey found that the two primary goals of landowners investing in brush management were to increase forage production and to conserve water (Kreuter et al. 2005). Other reasons included improvement of aesthetic values, benefit the next generation, improve wildlife habitat, and improve real estate value.

In 2007, the USDA Census of Agriculture accounted for more than 247,000 farming and ranching operations in the state. This represents an 8% increase since the 1997 Census. Texas gained about 1,900 new working farms and ranches annually during this 10-year period. However, the land base for Texas agriculture has decreased by approximately 2% during the same period. Average ownership size declined from 585 ac in 1997 to 527 ac in 2007. At 92.6M ac, native rangeland continues to be the prevailing general category of land use in Texas. Since 1997, the accumulated localized loss of native rangeland has exceeded 4.8M ac. According to accumulated data from county appraisal districts, more than 2.1M ac of farms, ranches, and forestlands were converted to other uses from 1997–2007. More than 40% of this land conversion was related to growth and development associated with population expansion in the state’s 25 highest growth counties. (Wilkins et al. 2009)

According to survey data from the Edwards Plateau, landowners are less inclined to invest in brush control if they are not reliant on livestock income (Garriga 1998). As the demographics of rangeland owners shift away from an emphasis on livestock production, and as long as fire continues to be suppressed, it is likely that woody cover will continue to increase unless incentives are provided to encourage brush management.

The National Resources Inventory is a statistical survey designed to help gauge natural resource status, conditions, and trends on the nation's non-federal land. Non-federal land includes privately owned lands, tribal and trust lands, and lands controlled by State and local governments. The NRI is conducted by the USDA-NRCS in cooperation with Iowa State University's Center for Survey Statistics and Methodology. Information about the condition of the land and related natural resources is needed at many different scales to inform decision makers.

The NRI Rangeland Resource Assessment (NRCS 2010; Herrick et al. 2010) focuses on information derived from NRI rangeland data collected on-site from 2003 to 2006.

According to the NRI Rangeland Resource Assessment, hydrologic function shows high proportions of land showing at least moderate departure in many parts of the region (Figure 2.1.5). This is due to the sensitivity of hydrologic function to both soil degradation and, frequently, changes in the plant community associated with invasive woody plants. Mesquite (mainly *Prosopis glandulosa*) and juniper (*Juniperus* spp.) are particularly widespread in this region (Figures 2.1.1, 2.1.2, 2.1.3, and 2.1.4). While native, they can and do increase in the absence of fire. Where increased woody cover is associated with reduced grass cover, infiltration capacity can decline with increased runoff in interspace areas between shrubs. Accelerated runoff over time can result in changes of natural water flow paths and the formation of interspace rills which may develop into gullies. Soil loss can be excessive and recovery on these sites can be slow. On shallow soils, these channels can quickly erode to bedrock. In contrast, dense grass cover and associated root mass tend to increase soil porosity, soil aggregate stability, and overall soil health.

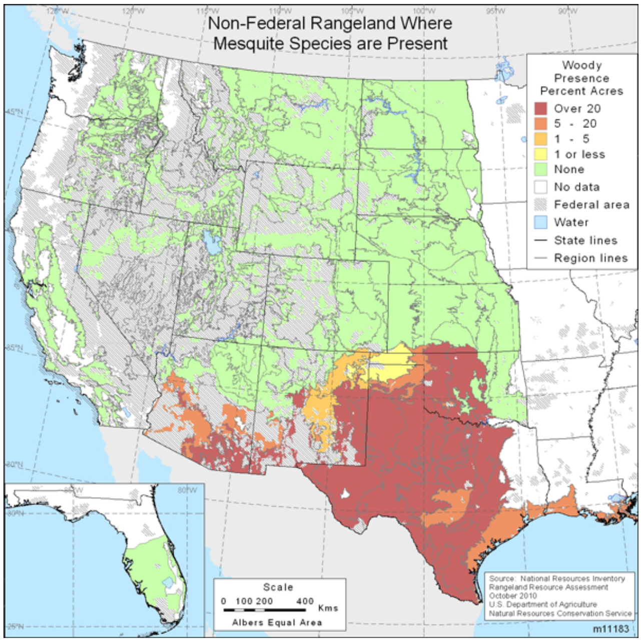

Figure 2.1.1 Non-federal rangeland where mesquite species are present (NRCS 2010)

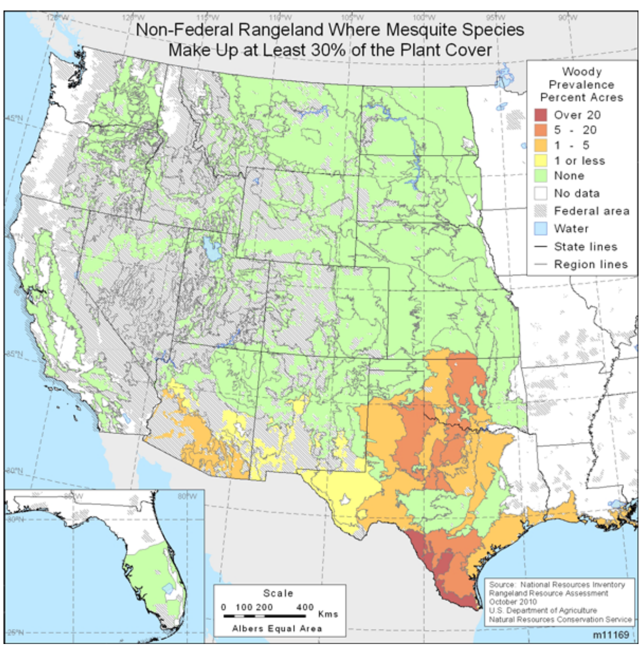

Figure 2.1.2 Non-federal rangeland where mesquite species make up at least 30% of the plant cover (NRCS 2010)

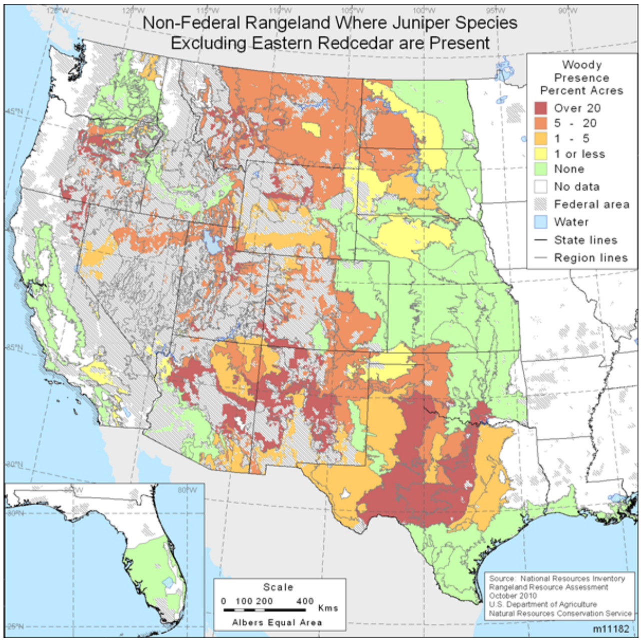

Figure 2.1.3 Non-federal rangeland where juniper species (excluding Eastern redcedar) are present (NRCS 2010)

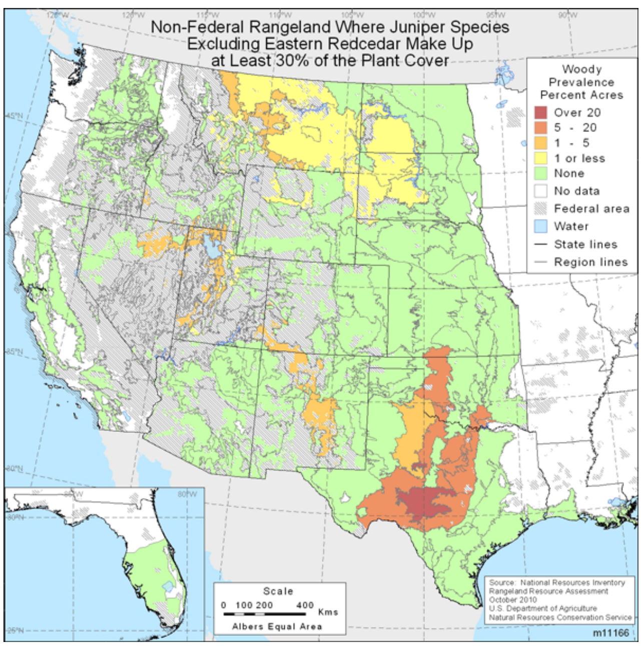

Figure 2.1.4 Non-federal rangeland where juniper species (excluding Eastern redcedar) make up at least 30% of the plant cover (NRCS 2010)

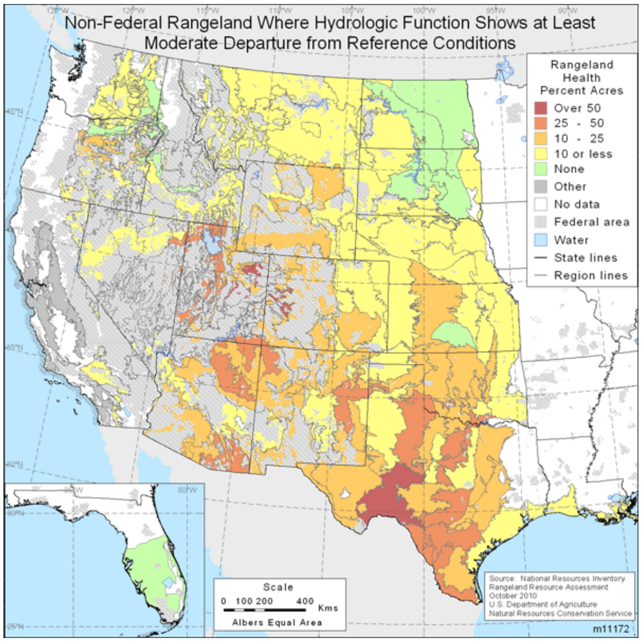

Figure 2.1.5 Non-federal rangeland where hydrologic function shows at least moderate departure from reference conditions (NRCS 2010)

Saltcedar poses a somewhat different problem. According to Shafroth (2006), "in the latter part of the 19th century, species of the non-native shrub saltcedar (*Tamarix* spp.) were introduced to the United States for use as ornamental plants and for erosion control. By 1877, some naturalized populations had become established, and by the 1960s, tamarisk was present along most rivers in the semi-arid and arid parts of the West and was quite abundant along downstream reaches of the major southwestern rivers such as the Rio Grande and Pecos (Figure 2.1.6). The principal period of tamarisk invasion coincided with changing physical conditions along western rivers. In many cases, these altered physical conditions appear to have been more favorable for tamarisk than native riparian competitors like cottonwoods and willows." Once established, saltcedar dominates all vegetation along rivers, lakes, and streams and consumes vast quantities of water. According to Sheng et al. (2007), "the distribution of saltcedar in North America includes waterways and reservoirs throughout the greater southwestern United States and portions of Mexico. Saltcedar reproductive attributes and greater tolerance to stressors such as water table fluctuation and salinity facilitated the conversion from more diverse native plant communities to saltcedar-dominated communities."

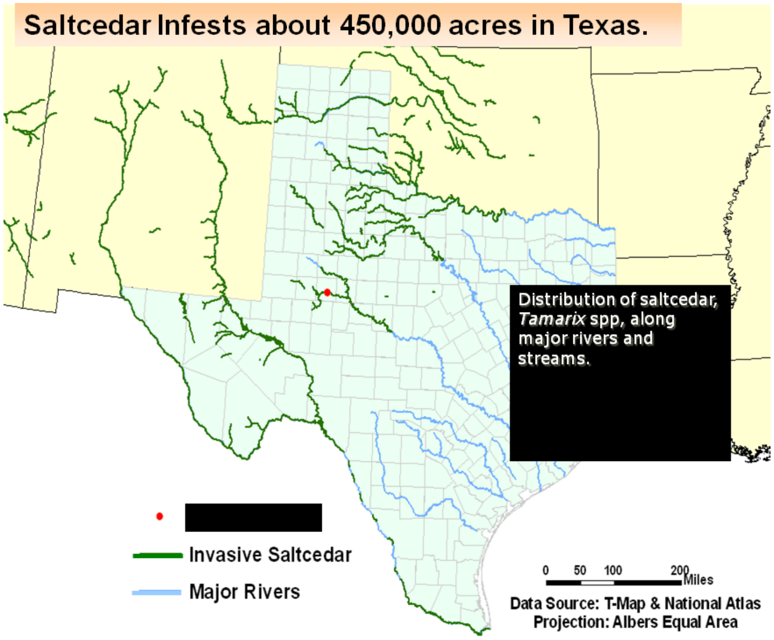

Figure 2.1.6 Saltcedar Infestation in Texas (Knutson 2013)

Section 2.2 Increasing Water Yields with Rangeland Management

Water yield following brush control has been investigated in several areas of the state. Studies by Thurow and Hester (1997), Carlson et al. (1990), and Weltz and Blackburn (1995) show that at sites with precipitation ranging from about 12 to 35 in per year, the majority of precipitation is used for ET. Following brush removal (original cover: 36% juniper, 24% oak), 16% of the precipitation went to deep drainage compared to none for the untreated watershed, an amount equal to 100,500 gal/ac/yr (Thurow and Hester 1997).

A major difference between controlling juniper (*Juniperus ashei* Bucholz) compared to mesquite is that control of juniper results in a much greater reduction in ET. This difference is due to the greater interception of rainfall by juniper and its evergreen nature compared to mesquite, and because juniper is normally associated with shallow sites, which facilitates the deep percolation of the water not lost to ET.

Literature summarizing water yield studies in the western U.S. and data from the Edwards Plateau in Texas indicate that a significant increase in water yield is possible if brush cover is converted to grassland or open savanna and if the area receives about 18 in/yr or more rainfall (Thurow 1998).

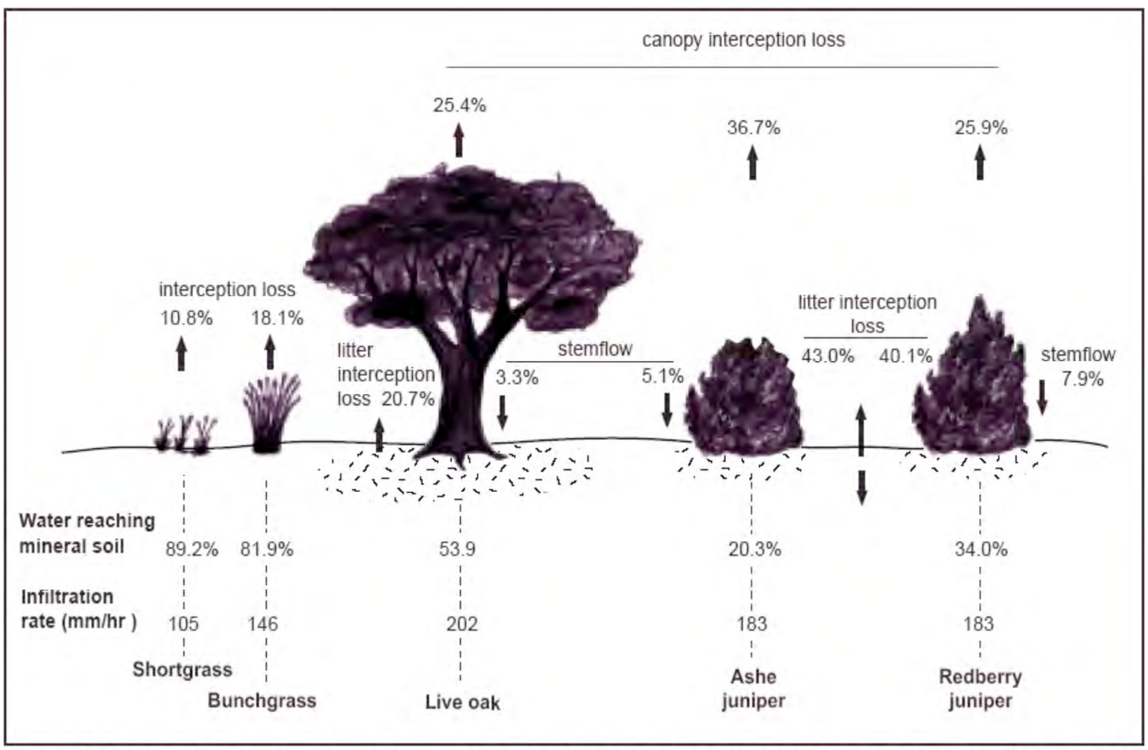

Figure 2.2.1 Influence of canopy cover type on amount of annual precipitation reaching mineral soil (Thurow and Hester 1997)

Though water supply enhancement following brush control has been investigated in several areas of Texas, the economic benefits and overall productivity of a brush control project may vary significantly depending on geology, physical characteristics of the water source that may be affected by the water supply enhancement efforts, quantity of brush, brush species, and potential impacts on threatened or endangered species.

ROCKY CREEK

Moseley (1983) (also TSSWCB 1987 and UCRA 2000) tells the story of Rocky Creek, a West Texas creek dry for decades that started flowing again, near San Angelo, thanks to ranchers and their conservation work in a 74,000 ac watershed.

“In the early 1960s landowners on five ranches, covering about half the watershed, began rootplowing, reseeding, treedozing, aerial spraying, and chaining. The ranchers received technical assistance and cost-share for this work through the Great Plains Conservation Program. The program was administered through local SWCDs in selected Great Plains counties by USDA-NRCS. West Rocky Creek flowed yearlong until the drought of 1918-1919, when it became an intermittent stream. By 1935, springs feeding the creek had been dried up by mesquite and other invading woody plants. Located in the Edwards Plateau region, West Rocky Creek is a tributary of the Middle Concho River about 20 miles west of San Angelo.

In 1964, following the accelerated range conservation program, one of the five ranchers noticed that a spring – dry since 1935 – had started flowing again. By replacing the water-hungry brush with a good grass cover, more rainfall soaked into the aquifer, recharging the dormant springs. By 1970, springs had begun flowing on all five ranches. All the conservation work was done in a manner that would benefit white-tailed deer and turkey. The role of sound grazing management cannot be overlooked. The grazing management on each ranch enhanced the cover of grasses on the watershed. This grass cover retarded the reinvasion of brush and helped hold water and soil on the land. The turf decreased the sediment load in surface water supplies. Although the brush succession was retarded, these ranchers periodically did maintenance brush work just to keep things in the desired balance.

Even though the rangeland improvements reduced erosion in the watershed and increased forage production for the ranchers' livestock, the story of West Rocky Creek may be more important to the residents of San Angelo. Water from the creek supplements the city's water supply reservoirs. The West Rocky Creek watershed yielded an estimated 525.6M gal annually. If the West Rocky Creek brush treatment were expanded to the entire watershed above San Angelo, one could predict a long lasting supply of clear water, increased livestock and wildlife production, and decreased sedimentation of downstream water supplies.”

Field studies in Texas have attempted to measure water yield enhancement by brush control at a catchment scale. Discussion of three watersheds follows.

CUSENBARY DRAW

Research on the AgriLife Research field station at Sonora shows that there is a very significant water yield potential associated with converting brush to grassland on a site with these characteristics (over 18 in/yr of rain, shallow soils with high infiltration rates overlying fractured limestone (i.e., karst), dense juniper-oak woodland cleared and replaced with shortgrass and midgrass species). These data were collected over a 10-year period from seven 10 ac catchments and supplemented with data on water movement through the soil using lysimeters (Redeker et al. 1998).

Similar estimates of vegetation effects on water yield were made for the Cusenbary Draw watershed, which includes part of the AgriLife Research field station at Sonora. The Cusenbary Draw watershed estimates were derived independently of the field data estimates and were obtained using the Simulation of Production and Utilization of Rangelands (SPUR-91) model (Redeker et al. 1998). The SPUR-91 model has been validated to be an effective tool for estimating water yield and livestock carrying capacity on rangeland sites throughout Texas (Carlson et al. 1995, Carlson and Thurow 1996). The amount of woody cover in 1955 and 1990 and the rate of change between these dates were calculated using image analysis technologies of aerial photography on each of the five rangeland sites delineated within the watershed (Redeker 1998). Literature and expert opinion were used to validate and refine the estimates of woody (juniper, oak, mesquite) and herbaceous (bunchgrass, shortgrass, forbs) cover. Based on woody cover-ET regression curves and GIS analysis, no brush management would result in a 35% decrease in water yield, while a hypothetical brush management program would increase water yield by 43% over the 1990 level (Wu et al. 2001).

Both the field study and modeling investigations conclude that water yield increases exponentially as brush cover declines in the treated area (i.e., very little change in water yield from dense brush canopy cover to about 15% brush canopy cover and a rapid rise in water yield from 15% to 0% brush canopy cover). These findings imply that it is necessary to remove most of the brush in the treatment area to maximize water yield potential (Thurow et al. 1997). This conclusion is corroborated by numerous anecdotal observations by ranchers and agency personnel with brush control experience in the region (Kelton 1975, Willard et al. 1993). The exponential pattern of water yield increase relative to a decrease in brush cover has also been postulated for the Colorado River basin (Hibbert 1983). The exponential relationship is believed to occur because the intraspecific competition among trees (Ansley et al. 1998) and interspecific competition with herbaceous vegetation results in little increase in water yield until the tree density becomes sparse. In other words, trees have a capability for luxuriant water use. If a stand is thinned the remaining trees will in a short time expand their root systems to use the extra water. Only when the thinning reduces tree cover to less than about 15% in a specific area is there a potential for significant yields of water. It should be noted that the brush canopy reflects the average density over the treated area, not necessarily the total number of plants in a watershed.

NORTH CONCHO RIVER

The results of a TSSWCB-funded multi-year study (Saleh et al. 2009) on the net water consumptive effects of upland mesquite control on ET found that significant water savings can be realized from control of upland mesquite. The study was conducted using a paired site approach in the North Concho River watershed at which ET measurements were collected using the eddy covariance technique and comparatively analyzed. The two adjacent mesquite-dominated experimental sites each consisted of about 200 ac. The field data indicated that the measured ET at the mesquite-treated site was lower than that of the untreated site during the mesquite growing season. For instance, the largest difference in measured ET (about 25%) between the treated and untreated sites was recorded during the peak mesquite growing season in 2008. Based on 952 daily ET measurements, the experimental data indicated that during the four-year study, the mesquite-dominated untreated site had a net consumption of over 46 mm (1.8 in) more water than the treated site. The findings indicate that during the four year period from 2005-2008, the treated site consumed approximately 0.7 inch less water per year than did the control site. These results, when extrapolated to the entire North Concho River watershed, very closely align with values predicted in the North Concho River Watershed Feasibility Study (UCRA 1999), which indicated water savings of about 26,400 gal/ac/yr for treating heavy mesquite in an area that receives about 20 in of average annual rainfall.

HONEY CREEK

The USGS, in cooperation with USDA-NRCS, TSSWCB, SARA, EAA, TPWD, GBRA, and the San Antonio Water System, evaluated the hydrologic effects of ashe juniper removal as a brush management conservation practice in and adjacent to the Honey Creek State Natural Area in Comal County. By removing the ashe juniper and allowing native grasses to reestablish in the area as a brush management conservation practice, the hydrology in the watershed might change. Using a simplified mass balance approach of the hydrologic cycle, the incoming rainfall was distributed to surface water runoff, ET, or groundwater recharge. After hydrologic data were collected in adjacent watersheds for three years, brush management occurred on the treatment watershed while the reference watershed was left in its original condition. Hydrologic data were collected for another six years. Groundwater recharge was not directly measured but potential groundwater recharge was calculated using a simplified mass balance approach.

The resulting hydrologic datasets were examined for differences between the watersheds and between pre- and post-treatment periods to assess the effects of brush management. The daily ET rates at the reference watershed and treatment watershed sites exhibited a seasonal cycle during the pre- and post-treatment periods, with intra- and interannual variability. Statistical analyses indicate the mean difference in daily ET rates between the two watershed sites is greater during the post-treatment than the pre-treatment period. During the post-treatment period, the percent average annual unit runoff in the reference watershed was similar to that in the treatment watershed, however, the difference in percentages of average annual ET and potential groundwater recharge were more appreciable between the reference and treatment watersheds than during the pre-treatment period.

Suspended-sediment loads were calculated from samples collected at the reference watershed and treatment watershed. The relation between suspended-sediment loads and streamflow calculated from samples collected did not exhibit a statistically significant difference during the pre-treatment period, whereas during the post-treatment period, relation between suspended-sediment loads and streamflow did exhibit a statistically significant difference. The relations indicate that for the same streamflow, the suspended-sediment loads calculated from the treatment watershed were generally less than suspended-sediment loads calculated from the reference watershed during the post-treatment period. (Banta and Slattery 2011)

This reduction in sediment load may be a result of the replacement grasses acting as an obstruction to overland flow, causing overland flow to move in a slower, more tortuous path, thereby resulting in deposition of some of the suspended sediment before the overland flow reaches the stream channel (Thurow et al. 1986).

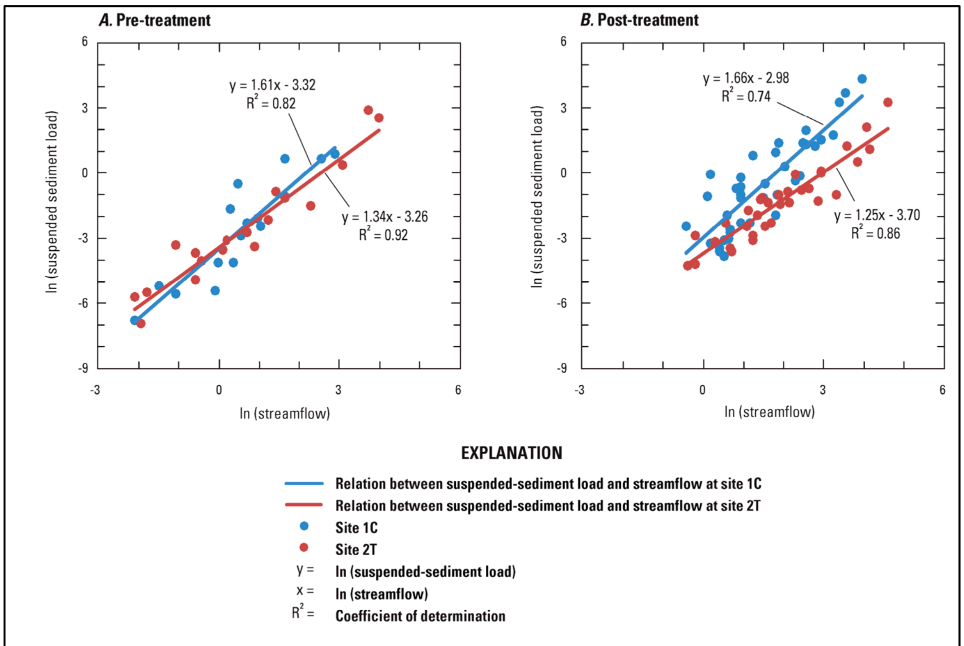

Figure 14. Suspended-sediment loads compared to streamflow during *A*, pre- and *B*, post-treatment periods at the reference watershed streamflow-gaging station site 1C (U.S. Geological Survey station 08167347 Unnamed tributary of Honey Creek site 1C near Spring Branch, Texas) and the treatment watershed streamflow-gaging station site 2T (U.S. Geological Survey station 08167353 Unnamed tributary of Honey Creek site 2T near Spring Branch, Tex.). Both datasets have been transformed through natural logarithm (ln), and the axes are ln scale.

Figure 2.2.2 Suspended Sediment Loads from USGS Honey Creek Study (Banta and Slattery 2011)

CONCLUSIONS

In summarizing scientific findings about the effects of brush control on rangelands, with emphasis on Texas and the southwestern United States, Jones and Gregory (2008) conclude:

For several decades, land managers have cleared brush species, such as mesquite and juniper, and observed increases in spring and stream flows. Scientists have also conducted numerous studies in which they have measured the effects of brush removal of different species on rangeland hydrology. These include the amount of rainfall that is intercepted and held by the plant leaves, surface runoff, spring flow, water use by individual plants and plant communities, fluctuation of shallow water tables, and streamflows. Considering this very diverse information, many scientists agree on several points:

- The roots of some brush species extract water from greater depths than do grasses and forbs, and brush control can reduce the total amount of water used by vegetation.
- Brush and other deep-rooted vegetation growing over shallow aquifers near streams can be expected to use large amounts of groundwater, likely reducing the amount in both the interconnected stream and aquifer.
- Removal of brush, like juniper and live oak, from upland areas some distance from streams may increase streamflow and/or recharge aquifers especially when:
    - The brush canopy is dense and intercepts substantial amounts of rainfall (e.g., dense juniper or live oak stands), effectively reducing the amount of rainfall reaching the soil surface, and
    - Soils, subsoils, and/or geologic strata are permeable, and streams in the area are fed by seeps and springs. Water can quickly percolate below the roots of grasses and forbs and move through subsurface pathways to local streams or aquifers.
- Brush control in upland areas is unlikely to increase significantly water yields if soils and geologic formations are not conducive to increased runoff and/or subsurface flows to streams or to aquifers.
- For brush control to have substantial long-term impacts on water yield, most or all of the woody vegetation in the treated area should be killed, and regrowth of brush and herbaceous vegetation should be controlled so that it is less dense and more shallow rooted than the pretreatment vegetation.
- New science-based tools (e.g., GIS and spatial analysis) can help pinpoint locations where brush control should substantially increase water flows in streams.
- A geographically targeted brush control program with careful scientific verification of impacts is needed to guide long-term brush control policies.

Rainwater et al. (2008) discusses various factors critical to estimation of water yield enhancement:

Changes in the water delivery characteristics of watersheds resulting from vegetative manipulations have been explored, studied, and reported for many years across a multitude of ecological settings. If there is one common thread in all of these reports, it is the fact that the results frequently are not consistent with expectations (Wilcox et al. 2008). Stated in a more practical vernacular, the response to a question "What will happen if?" should probably be, "It depends."

- it depends on all of the specific physical characteristics of a given watershed (such as geology, soils, topography, and land use)
- it depends on the sequence of meteorological events that may or may not lead to the generation of runoff or infiltration
- it depends on the general climatic conditions present on the watershed
- it depends on the type and species of vegetation that is being manipulated
- it depends on how the vegetation was manipulated (e.g., chemically, mechanically, by fire)
- it depends on the type and species of vegetation (if any) that replaces the one being manipulated
- any reliable conclusions depend on having accurate water yield data before and after treatment upon which to base judgments as to the impact of the particular treatment

Archer et al. (2011) critically evaluated brush management as a rangeland conservation strategy for the USDA-NRCS Conservation Effects Assessment Project:

Understanding the drivers of tree/shrub encroachment can help identify when, where, how, and under what conditions management might most effectively prevent or reverse woody plant proliferation. Traditional explanations center around intensification of livestock grazing, changes in climate and fire regimes, the introduction of non-native woody species, and declines in the abundance of browsing animals. Likely all these factors have interacted to varying degrees, and the strength and nature of these interactions likely varies from one biogeographic location to another. Woody plant encroachment has long been of concern to rangeland managers (Leopold 1924).

Integrated brush management systems (Scifres et al. 1985; Brock 1986; Hamilton et al. 2004) are long-term planning processes that move away from a purely livestock production perspective and toward management of rangelands for multiple uses and values. The integrated brush management systems planning process begins by identifying management goals and objectives for a specific site and the surrounding management unit. These might include increasing forage production; maintaining or promoting suitable wildlife habitat; augmenting stream flow or groundwater recharge; controlling invasive species; reducing wildfire risk; or preserving grassland and savanna ecosystems. Specific objectives are refined on a comprehensive inventory of ecosystem components (plants, animals, and soils), projecting the responses of those components to brush treatment alternatives, and considering the effects of treatment alternatives on management goals on other sites (Hanselka et al. 1996). Brush management techniques (chemical, mechanical, biological, and prescribed burning) differ with respect to environmental impacts, implementation costs, efficacies, and treatment longevities. Thus, the integrated brush management systems approach advocates consideration of the type and timing of a given brush management technology and makes explicit allowances for consideration of the type and timing of follow-up treatments.

Section 2.3 Variables Influencing Water Yield

Water yield (runoff and deep drainage) can be estimated using the following water balance equation:

> Runoff + Deep Drainage = Precipitation – Evapotranspiration.

The components of the water balance equation are defined as follows:

> *Evapotranspiration*. The combination of transpiration and evaporation where:
>
> > *Transpiration.* The process by which water vapor is released to the atmosphere by passing through leaf tissue.
> >
> > *Evaporation.* The process by which water vapor enters the atmosphere from the soil or surface water. Another source of evaporation is precipitation that has adhered to plants which then directly passes back to the atmosphere — this is known as interception loss.
>
> *Runoff.* Water that exits the watershed via overland flow.
>
> *Deep Drainage.* Water that exits the watershed via percolating through the soil beyond the reach of plant roots.

This implies that water yield can be increased if ET can be decreased through vegetation management (Thurow 1998). Many variables influence the degree to which water will exit a site via ET, runoff, or deep drainage.

CLIMATIC FACTORS

Precipitation characteristics such as amount, intensity, distribution over time, and form (i.e., rain or snow) influence the likelihood of runoff and deep drainage. It is more likely that runoff will occur when the rainfall is intense and/or occurs as large, prolonged storms. Deep drainage is most likely during prolonged rainy periods. If the rainfall is gentle and occurs in a series of small storms the chance for water yield is much lower.

The potential ET rate is influenced by temperature, humidity, and wind. In an arid environment the water will quickly evaporate from the soil and the transpiration demand from plant leaves will be very high. A high potential ET rate lowers the chances that water will have the time needed to percolate through the soil profile and escape uptake by plant roots. Many aquifers have a better chance of recharging during the winter because many of the plants have lost their leaves and because the low temperature results in a low ET rate.

VEGETATION FACTORS

The leaf surface area and type of cover determine the amount of water that can be held in the canopy and evaporate back to the atmosphere (interception loss). At the AgriLife Research field station at Sonora it was documented that juniper and the associated leaf litter have an annual interception loss averaging 73% of precipitation, compared with 46% interception loss for live oak and 14% interception loss for grass (Thurow and Hester 1997). These data dramatically indicate that the amount of water reaching the soil is markedly different among vegetation types. The leaf surface area and type of cover also influence the amount of water that will return to the atmosphere via transpiration. On rangelands with a dense juniper cover essentially all of the rainfall returns to the atmosphere by either evaporation (in the form of interception loss) or transpiration (i.e., the small amount of water that does reach the soil is taken up by the trees). Therefore, rangeland with dense juniper cover would have little potential for water yield compared to grassland, which has a much lower ET loss and allows more water to leave the site via either runoff or deep drainage.

The amount and type of cover are often the most important variables affecting infiltration rate (water movement into the soil) at a particular site. Plant cover dissipates the erosive energy of raindrops before they strike the soil. If cover is not present, the pores into the soil will likely be clogged with soil particles dislodged by raindrop impact. This creates a "wash-in" layer at the soil surface which restricts infiltration and accelerates erosion.

Since maintenance of productivity potential is an inherent characteristic of sound range management, accelerated erosion resulting from degraded infiltration characteristics is not acceptable. It is, therefore, important to maintain a type of cover that will protect the soil while having as little ET loss as possible. On Texas rangelands, a healthy grass cover can hold the soil in place and will have the lowest ET (and highest water yield) of the sustainable cover options.

SOIL FACTORS

The texture and structure of the soil is a primary determinant of how fast water can percolate through the soil. The textural and structural characteristics combined with soil depth determine how much water can be stored in the soil after it has had a chance to drain (field capacity). The geologic characteristics underlying the soil influence the amount of and rate at which water will exit a site via deep drainage. For example, the Edwards Plateau is characterized by shallow soils with a rapid infiltration rate underlain by fractured limestone. Consequently, the potential for deep drainage leading to aquifer recharge is high. Deep, coarse-textured soils, such as those overlying the Carrizo-Wilcox aquifer, also have a high aquifer recharge potential because of their rapid transmissive characteristics and low water retention capacity. These characteristics make it likely that much of the water yield associated with a change from brush to grass dominance will occur as deep drainage. In contrast, a typical site in the Rolling Plains ecoregion of North Central Texas is characterized by deep silty clay soil with a high water retention capacity and a slow drainage rate. As a result, very little water is lost to deep drainage (Carlson et al. 1990). The same is true of the clay soils of the Blackland Prairie ecoregion. Any extra water yield associated with a change from brush to grass dominance on a site with poor deep drainage potential will likely occur as runoff.

TOPOGRAPHIC FACTORS

The steepness and length of slope affects the potential for runoff and the erosion hazard. It is a generally accepted forestry practice that trees should not be cleared from hillsides with a 20% slope or more (FAO 1977). Many areas in Central Texas with slopes of this magnitude were historically forested "cedar breaks," probably because the associated rocky character made it difficult for them to sustain a natural fire. These sites should not be considered for brush control efforts intended to increase water yield.

CONCLUSIONS

The basis for using brush management to increase water yield is founded on the premise that shifting vegetation composition from species associated with high ET potential (trees and shrubs) to species with lower ET potential (grass) will increase water yield. Water yield tends to decrease as woody cover increases because, compared to grasses, trees and shrubs have:

(1) a more extensive canopy which catches precipitation which evaporates back to the atmosphere (i.e., interception loss),
(2) a greater leaf area from which transpiration can occur,
(3) a more extensive root system with greater access to soil water,
(4) a greater ability to extract water from very dry soil, and
(5) many invasive woody species are evergreen allowing rapid resumption of water use when it becomes available (as opposed to most grasses which senesce during dry periods and require time to re-establish green tissue).

Climate and soil traits influence whether reduction in transpiration and interception losses resulting from brush to grass conversion would be offset by increased evaporation from soil. An analysis of climate, ET, and field runoff measurements indicated that sites with tree and shrub communities in the Colorado River basin of the western U.S. need to receive over 18 in/yr of precipitation and need to have a potential ET of over 15 in/yr to yield significantly more water if converted to grasslands (Hibbert 1983). Since all regions of Texas have a potential ET of over 15 in/yr, these data suggest that a reasonable criterion for deciding where brush control is likely to increase water yield is to concentrate on areas that receive at least 18 in/yr of rain.

In general, conversion of cover from brush to grass does not influence water yield on sites that receive less than 18 in/yr because the extra water that reaches the ground and the reduced transpiration loss is offset by high evaporation from the soil. An exception to this is saltcedar which grows in riparian areas and extracts water from shallow aquifers recharged by the source stream or waterbody. Studies in many other forest and rangeland ecosystems throughout the world corroborate that a water yield increase can occur when the dominant vegetation cover is shifted from brush to grass (Douglass 1983; Jofre and Randal 1993) in areas that receive at least 18 in/yr precipitation and have at least 15 in/yr potential ET.

Section 2.4 Brush Species in Texas

All major land resource areas in Texas have significant brush infestations; however, different species predominate in different regions. Table 2.4.1 shows the major brush species and level of infestation in Texas based on brush surveys conducted by USDA-NRCS (1982 and 1987 NRI) (compiled in TSSWCB 1991). While the surveys are dated (27-32 years), these acreages still illustrate the magnitude of Texas' brush problem. While not all species of brush are significant users of water (e.g., prickly pear), others have been shown to drastically reduce water yield in a watershed.

Table 2.4.1 Acres of brush for different species and density ranges in Texas (TSSWCB 1991)

Species	Light Canopy 1-10% Cover		Moderate Canopy 11-30% Cover		Heavy Canopy >30% Cover	
	1982	1987	1982	1987	1982	1987
Agarito	8,370,500	5,336,100	303,500	272,700	29,500	11,600
Ashe juniper	4,398,300	2,875,300	2,000,800	1,949,300	1,214,700	1,904,400
Baccharis	288,800	122,000	44,200	25,700	7,000	9,000
Blackbrush	3,780,100	2,167,200	2,068,400	2,445,000	602,200	623,000
Blackjack oak	765,700	401,700	365,700	164,200	52,500	50,500
Broom snakeweed	5,560,300	2,607,700	1,987,700	2,512,800	270,600	967,200
Catclaw acacia	7,045,400	3,554,200	611,600	335,700	13,700	1,700
Cenizo	258,300	107,300	12,500	21,000	0	0
Chinese Tallow[1]	-	-	-	-	-	507,400
Condalias/lotebush	9,168,400	6,991,700	551,100	594,000	88,300	23,100
Creosotebush	4,830,600	4,212,500	3,027,000	2,324,300	246,200	134,800
Eastern redcedar	633,800	374,700	166,900	101,000	97,000	27,900
Elbowbush	331,600	174,800	69,700	60,800	13,600	1,600
Elms	1,939,800	996,000	671,400	553,500	315,600	341,100
Granjeno	4,939,400	3,374,100	486,000	735,000	86,800	1,200
Guajillo	1,975,400	1,162,300	981,200	1,081,600	239,600	401,200
Huisache	745,700	589,900	194,000	145,500	63,500	46,600
Live oak	6,067,500	4,321,000	3,401,500	4,141,600	1,112,500	1,076,100
Macartney rose	176,100	70,300	56,900	146,000	21,900	0
Mesquite	32,162,700	24,936,500	14,690,900	16,670,800	4,262,900	5,610,000
Post oak	2,027,200	1,277,500	1,642,300	1,524,900	1,642,400	1,536,200
Prickly pear	28,688,500	19,642,000	1,686,100	2,176,200	170,900	189,200
Redberry juniper	6,900,600	6,133,600	2,532,400	2,707,800	414,700	558,300
Saltcedar[2]	-	-	-	-	563,500	-
Sand sagebrush	2,764,300	2,494,600	1,032,700	1,168,800	239,800	292,700
Sand shinoak	301,600	60,100	350,200	257,200	362,000	600,900
Tarbush	2,301,600	2,083,300	791,300	594,900	50,300	85,500
Tasajillo	4,475,800	3,092,000	271,500	283,100	16,600	0
Texas persimmon	5,833,600	3,315,900	850,600	767,600	124,200	54,400
Twisted acacia	1,061,500	748,000	156,800	181,600	0	0
Whitebrush	2,593,500	1,663,000	605,800	763,000	184,400	318,800
Yaupon	831,000	515,900	568,700	654,100	322,600	205,300
Yucca	13,353,800	8,279,600	601,300	499,300	12,600	0

1 Chinese tallow infestation for 1990 from a 1991 survey by USDA-NRCS. Infestation by the year 2000 was estimated at over 900,000 acres. Percent canopy cover was not provided.

2 Saltcedar infestation from 1982 USDA-NRCS brush survey.

Section 2.5 General Vegetative Communities Across Texas – Gould's Ecoregions

Texas is a diverse State with a broad range of climate and soil types. Within the combinations of soils and climates, there are distinctive vegetative communities that predominate. Gould, et al. (1960) described 10 vegetative communities across the State.

Figure 2.5.1 Gould's Ecoregions of Texas [Gould et al. 1960 (here modified by TPWD 2011)]

BLACKLAND PRAIRIE

The Blackland Prairie intermingles with the Post Oak Savannah in the southeast and has divisions known as the San Antonio and Fayette Prairies. This rolling and well-dissected prairie represents the southern extension of the true prairie that occurs from Texas to Canada. The soils are inherently productive and fertile, but many have lost productivity through erosion and continuous cropping.

This once-luxuriant tallgrass prairie was dominated by little bluestem, big bluestem, indiangrass, tall dropseed (*Sporobolus asper* var. *asper*), and Silveus dropseed (*S. silveanus*). Minor species such as sideoats grama (*Bouteloua curtipendula*), and buffalograss (*Buchloe dactyloides*) have increased with grazing pressure. Mesquite, huisache, oak, and elm are common invaders on poor-condition rangelands and on abandoned cropland. Oak, elm, cottonwood, and native pecan (*Carya*) are common along drainages.

About 98% of the Blackland Prairie was cultivated to produce cotton, sorghum, corn, wheat, and forages during the latter part of the 19^{th} Century and the first part of the 20^{th} Century. Since the 1950s, pasture and forage crops for the production of livestock have increased, and now only about 50% of the area is used as cropland. Pastures occupy more than 25% of the land area, and the rest is used as rangeland. Small remnants of native vegetation exist for grazing or for hay production. Livestock production with both cow-calf and steer operations are the major livestock use. Winter cereals are used extensively for livestock grazing in conjunction with pasture forages. Mourning dove and bobwhite quail on the uplands and squirrel along streams are the most important game species.

CROSS TIMBERS

The Cross Timbers and Prairies area in North Central Texas includes the Cross Timbers, Grand Prairie, and North Central Prairies land resource areas. This area represents the southern extension of the Central Lowlands and the western extreme of the Coastal Plains. The wide variances in geologic formations bring about sharp contrasts in topography, soils, and vegetation.

Climax vegetation is composed primarily of big bluestem, little bluestem, indiangrass, switchgrass, Canada wildrye, minor amounts of sideoats grama, blue grama (*Bouteloua gracilis*), hairy grama, Texas wintergrass, and buffalograss. The minor species have generally increased with grazing.

Past management and cultivation have caused the uplands to be covered mostly by scrub oak, mesquite, and juniper with mid- and shortgrass understories. The bottomland trees are primarily hardwoods such as pecan, oak, and elm but have been invaded by mesquite.

About 75% of the Cross Timbers and Prairies area is used as range and pasture. Major crops on the sandy Cross Timber soils are peanuts, fruits, sorghum, wheat, oats, corn, and forages. Dairy operations are common, but beef cattle cow-calf operations are the predominant livestock activities. Sheep and goat operations occur in the southern parts. Most holdings are small mixed farming and ranching operations.

White-tailed deer, raccoon, squirrel, quail, and mourning dove are locally plentiful and provide some commercial hunting. Stock ponds and lakes on tributaries of the Brazos River and the Trinity River provide recreational fishing.

EDWARDS PLATEAU

The Edwards Plateau area includes 1.45M ac known as the Granitic Central Basin in Llano and Mason Counties. The Balcones Escarpment forms the distinct boundary of the Edwards Plateau on its eastern and southern borders and outlines what is known as the Texas Hill Country.

The area is a deeply dissected, rapidly drained stony plain having broad, flat to undulating divides. The original vegetation was grassland or open savannah-type plains with tree or brushy species found along rocky slopes and stream bottoms. Tallgrasses such as cane bluestem (*Bothriochloa barbinodis* var. *barbinodis*), big bluestem, indiangrass, little bluestem, and switchgrass are still common along rocky outcrops and protected areas having good soil moisture. These tallgrasses have been replaced on shallow xeric sites by midgrasses and shortgrasses such as sideoats grama, buffalograss, and Texas grama.

The western part of the area comprises the semi-arid Stockton Plateau, which is more arid and supports short- to midgrass mixed vegetation.

Common woody species are live oak, sand shin oak (*Quercus havardii*), post oak, mesquite, and juniper. The eastern and southern edges of the Stockton Plateau support dense stands of ashe juniper (*Juniperus ashei*), whereas redberry juniper (*Juniperus pinchotii*) increases to the north and west.

The Edwards Plateau is 98% rangeland; arable lands are found only along narrow streams and some divides. The rangeland is used primarily for mixed livestock (combinations of cattle, sheep, and goats) and wildlife production. The area is the major wool- and mohair-producing region in the United States, providing perhaps 98% of the nation's mohair. It also supports the largest deer population in North America. Most ranches are managed for livestock as the major enterprise, but wildlife production is increasingly important. Exotic big game ranching is important, and axis, sika, and fallow deer and blackbuck antelope are increasing in number (Traweek 1985). Management for all resources, livestock, wildlife, and recreation, provides the best use of the rangeland although other products such as cedar oil and wood products have local importance. Forage, food, and fiber crops such as sorghum, peanuts, plums, and peaches are well-adapted to arable land.

GULF PRAIRIES

The Gulf Prairies and Marshes, covering approximately 500,000 ac, are on a narrow strip of lowlands adjacent to the coast and the barrier islands, which extend from Mexico to Louisiana. The Gulf Prairies, about 9M ac, include the nearly flat plain extending 30 to 80 miles inland from the Gulf Marshes.

The Gulf Prairies and Marshes are a low, wet, marshy coastal area, commonly covered with saline water, and range from sea level to a few feet in elevation. The Gulf Prairies are nearly level and virtually undissected plains having slow surface drainage and elevations from sea level to 250 ft.

The original vegetation types of the Gulf Prairie were tallgrass prairie and post oak savannah. However, trees and shrubs such as honey mesquite (*Prosopis glandulosa*), oaks (*Quercus*), and acacia (*Acacia*) have increased and thicketized in many places. Characteristic oak species are live oak (*Quercus virginiana*) and post oak (*Q. stellata*). Typical acacias are huisache (*Acacia farnesiana*) and blackbrush (*A. rigidula*).

Principal climax grasses of the Gulf Prairie are Gulf cordgrass (*Spartina spartinae*), big bluestem (*Andropogon gerardii* var. *gerardii*), little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), eastern gamagrass (*Tripsacum dactyloides*), gulf muhly (*Muhlenbergia capillaris*), tanglehead (*Heteropogon contortus*), and many species of panicum and paspalum.

The Gulf Marsh areas, being variously salty, support species of sedges (*Carex* and *Cyperus*), rushes (*Juncus*), bulrushes (*Scirpus*), several cordgrasses (*Spartina*), seashore saltgrass (*Distichlis spicata* var. *spicata*), common reed (*Phragmites australis*), marshmillet (*Zizaniopsis miliacea*), longtom (*Paspalum lividum*), seashore dropseed (*Sporobolus virginicus*), and knotroot bristlegrass (*Setaria geniculata*).

The low marshy areas provide excellent natural wildlife habitat for upland game and waterfowl. The higher elevations of the Gulf Marshes are used for livestock and wildlife production. Ranch units are mostly in large landholdings. These marshes and barrier islands contain a National Seashore, and many TPWD State Parks and Wildlife Management Areas and USFWS National Wildlife Refuges. Urban, industrial, and recreational developments have increased in recent years. Most land is not well-suited for cultivation because of periodic flooding and saline soils. The Gulf Prairies are used for crops, livestock grazing, wildlife production, and increasingly for urban and industrial centers. About one-third of the area is cultivated mostly for rice, sorghum, corn, and pastures. Bermudagrass and several introduced bluestems are common pasture grasses.

In the Gulf Prairies and Marshes, ranches are primarily cow-calf operations that use forage produced from rangeland and pasture. Some of the area is cropped. Recreation, hunting, and fishing provide excellent multiple-use opportunities in the Gulf Prairies and Marshes.

HIGH PLAINS

The High Plains area is part of the Southern Great Plains. It is separated from the Rolling Plains by the Llano Estacado Escarpment and dissected by the Canadian River breaks in the northern part. Notable canyons include Tule and Palo Duro along the Caprock. This relatively level plateau contains many shallow siltation depressions, or playa lakes, which sometimes cover as much as 40 ac and contain several feet of water after heavy rains. These depressions support unique patterns of vegetation within their confines.

The original vegetation of the High Plains was variously classified as mixed prairie, shortgrass prairie, and in some locations on deep, sandy soils as tallgrass prairie. The High Plains area characteristically is free from brush, but sand sagebrush and western honey mesquite (*Prosopis glandulosa* var. *torreyana*) have invaded the sandy and sandy loam sites along with prickly pear and yucca (*Yucca*).

About 60% of the area is cropland, half of which is irrigated. Cotton, corn, sorghum, wheat, vegetables, and sugar beets are major crops. Winter cereals are used for stocker operations in preparation for feedlotting on the extensive grain supplies produced on the High Plains. Rangeland grazing is important on about 40% of the area. Few cow-calf operations exist, but stocker operations are common.

High winds, dry winters, and low annual rainfall present problems for cultivation and erosion control. As groundwater availability diminishes, use of pasture and range for livestock production increases.

Pronghorn antelope were once common, but now only remnant populations provide hunting. Quail and mourning dove are abundant, and mule deer, turkey, and exotic aoudad sheep provide hunting along the breaks and canyons of the Caprock. Many playa lakes provide excellent migratory waterfowl habitat.

PINEYWOODS

The Pineywoods lie entirely within the Gulf Coastal Plains, which extend into Texas for 75 to 125 miles west of the Louisiana border. The area is a nearly level to gently undulating, locally hilly, forested plain. The dominant vegetation type is a mixed pine-hardwood forest on the uplands and a mixed hardwood forest on the lowlands. Native pines are loblolly (*Pinus taeda*), shortleaf (*P. echinata*), and longleaf (*P. palustris*). Slash pine (*P. elliottii*), a native of the southeastern United States, has been widely planted on thousands of acres. Hardwoods grow in mixed stands with pines in the uplands but are generally dominant along major streams. The principal hardwoods in the region are sweetgum (*Liquidambar styraciflua*), oaks (*Quercus*), water tupelo (*Nyssa aquatica*), blackgum (*N. sylvatica*), magnolias (*Magnolia*), elms (*Ulmus*), cottonwoods (*Populus*), hickories (*Carya*), walnuts (*Juglans*), maples (*Acer*), American beech (*Fagus grandifolia*), ashes (*Fraxinus*), and baldcypress (*Taxodium distichum*).

Many species of shrubs, vines, forbs, and grasses occupy the forest floor, prairies, and cutover areas not used for cropland.

Common understory shrubs and vines are southern wax-myrtle (*Myrica cerifera*), American beautyberry (*Callicarpa americana*), grapes (*Vitis*), blueberries (*Vaccinium*), hawthorns (*Crataegus*), greenbriars (*Smilax*), rattan-vine (*Berchemia scandens*), trumpet honeysuckle (*Lonicera sempervirens*), dewberries (*Rubus*), and poison ivy (*Toxicodendron radicans*). The area is noted for its flowering understory shrubs such as dogwoods (*Cornus*), redbud (*Cercis canadensis*), and black-haws (*Viburnum*).

Timber production is the leading land use in the Pineywoods. Forest grazing, pasture, feed grains, forages, fruits, and vegetables are secondary common land uses. Pine plantations and pastures currently occupy many areas previously forested or cultivated. Introduced grasses and the cultivation of legumes and use of fertilizer make this a highly productive pasture area. The forests, rangelands, and pastures are used for timber, livestock, wildlife habitat, recreation, and water production. The major livestock enterprise is the cow-calf operation. Herbage production in forests is generally negatively influenced by forest overstory canopy. Reservoirs provide recreation, including fishing, hunting, and swimming.

POST OAK SAVANNAH

The Post Oak Savannah lies just to the west of the Pineywoods and mixes considerably with the Blackland Prairies area in the south. This area includes the entire Claypan land resource area of Texas, which is part of the Southern Coastal Plains. The Post Oak Savannah is a gently rolling, moderately dissected wooded plain.

Short oak trees occur in association with tallgrasses. Thicketization occurs in the absence of recurring fires or other methods of woody plant suppression. This distinctive pattern of predominantly post oak and blackjack oak (*Quercus marilandica*) in association with tallgrasses also characterizes the vegetation of the Cross Timbers and Prairies vegetational area. Associated trees are elms, junipers (*Juniperus*), hackberries (*Celtis*), and hickories. Characteristic understory vegetation includes shrubs and vines such as yaupon (*Ilex vomitoria*), American beautyberry, coralberry (*Symphoricarpos orbiculatus*), greenbriar, and grapes.

Climax grasses are little bluestem, indiangrass, switchgrass (*Panicum virgatum*), silver bluestem (*Bothriochloa saccharoides*), Texas wintergrass (*Stipa leucotricha*), brownseed paspalum, purpletop, narrow leaf woodoats (*Chasmanthium sessiliflorum*), and beaked panicum (*Panicum anceps*).

The area is well-suited to grain crops, cotton, vegetables, and fruit trees. It was extensively cropped through the 1940s, but many acres have since been returned to native vegetation or pastures. Pasturelands have frequently been seeded with introduced species such as bermudagrass, bahiagrass, and clover.

Deer, turkey, quail, and squirrel are perhaps the most economically important wildlife species for hunting enterprises although many other small mammals and birds exist in the region. The major livestock enterprise is mixed cow-calf operations with many small herds on small landholdings. Livestock use either pastures, or the woodland areas for forage throughout the year. Wheat, oats, and rye are often planted for winter pasture.

ROLLING PLAINS

The Rolling Plains area (24M ac) coincides with the Rolling Plains land resource area of the southern Central Lowlands. The area is between the High Plains and the Cross Timbers in the northern part of the state. It is a nearly level to rolling plain having moderate to rapid surface drainage.

The original prairie vegetation included tall-, mid-, and shortgrasses such as little bluestem, big bluestem, sand bluestem (*Andropogon gerardii* var. *paucipilus*), sideoats grama, indiangrass, switchgrass, hairy grama, blue grama, and buffalograss on the uplands, and Canada wildrye and western wheatgrass (*Elytrigia smithii*) on the moister sites. Plant retrogression under continued overgrazing and suppression of fires is from a mid- and tallgrass-dominated community to shortgrasses, shrubs, and annuals.

Mesquite, lotebush, prickly pear, algerita (*Berberis trifoliolata*), and tasajillo are common invaders on all soils. Shinnery oak and sand sagebrush (*Artemisia filifolia*) invade the sandy lands, and redberry juniper has spread from rocky slopes to grassland areas. Dense stands of these species can be found throughout the Rolling Plains on overgrazed rangeland and abandoned cropland.

More than 75% of the area is rangeland, but dryland and irrigated sorghum, small grain, cotton, and forages are important crops. Livestock production, the major enterprises being cow-calf and yearling operations, includes use of rangeland forage, crop residue, and winter cereals. The intermixing of rangeland and cropland allows habitat for wildlife such as mourning dove, quail, white-tailed deer, and turkey, providing good to excellent recreational hunting opportunities.

SOUTH TEXAS PLAINS

The South Texas Plains lie south of a line from San Antonio to Del Rio. This area is the western extension of the Gulf Coastal Plains merging with the Mexico Plains on the west. The area is a nearly level to rolling, slightly to moderately dissected plain.

The original vegetation was an open grassland or savannah-type along the coastal areas and brushy chaparral-grassland in the uplands. Originally, oaks and mesquite and other brushy species formed dense thickets only on the ridges, and oak, pecan, and ash were common along streams. Continued grazing and suppression of fires altered the vegetation to such a degree that the region is now commonly called the Texas Brush Country. Many woody species have increased, including mesquite, live oak, acacia, Brazilian bluewood (*Condalia obovata* Hook.), spiny hackberry (*Celtis pallida*), whitebrush (*Aloysia gratissima*), lime pricklyash (*Zanthoxylum fagara*), Texas persimmon (*Diospyros texana*), shrubby blue sage (*Salvia ballotiflora*), and lotebush (*Zizyphus obtusifolia*).

Because the South Texas Plains lie almost entirely below the hyperthermic line, introduced tropical species do well. The introduced species buffelgrass (*Cenchrus ciliaris*) has proliferated and is common on loamy to sandy soils in the western half of the area. Coastal bermudagrass, kleingrass (*Panicum coloratum*), and rhodesgrass (*Chloris gayana*) are also common introduced species in pastures.

Range is the major land use, but irrigated and dryland cropping of cotton, sorghum, flax, small grains, and forages are also important. Citrus, vegetables, and sugarcane do well in the Lower Rio Grande Valley. Many acres are in large landholdings, such as the King Ranch. Livestock production is primarily cow-calf range operations, and wildlife production for hunting and recreational use is increasingly important. The South Texas Plains area is known nationwide for its large white-tailed deer. Quail, mourning dove, turkey, feral hogs, and javelina are other major game species. Stocker operations and feedlot operations are intermixed with cow-calf operations. Sheep and goat enterprises, once common throughout the area, are now confined mostly to the northern part because of coyote predation. Integrated use of range, crops, and forages is increasing as is vegetable and peanut production where irrigation is possible.

TRANS-PECOS

The Trans-Pecos area in Far West Texas is traversed by the eastern chain of the Rocky Mountains into the Basin and Range Province and is typical of the southwestern United States. Guadalupe Peak, having an elevation of 8,751 ft, of the Guadalupe Mountains, is the highest point in Texas. Surrounding peaks are El Capitán, Shumard, Bartlett, and Pine Top, all exceeding 8,000 ft. Mount Emory in the Chisos Mountains and Mount Locke in the Davis Mountains are 7,825 ft and 8,382 ft high, respectively. Notable canyons and gorges are Santa Elena, Boquillas, and Mariscal on the Big Bend of the Rio Grande; and McKittrick in the Guadalupe Mountains.

The original vegetation ranged from desert grassland and desert shrub on lower slopes and elevations through juniper, pinyon pine (*Pinus edulis*), and Mexican pinyon (*P. cembroides*) at mid elevations. The mountains support ponderosa pine (*Pinus ponderosa*) and forest vegetation on the higher slopes. Principal vegetation types of the basins are creosotebush (*Larrea tridentata*), tarbush (*Flourensia cernua*), catclaw acacia (*Acacia greggii*), catclaw mimosa (*Mimosa biuncifera*), whitethorn (*Acacia constricta*), yucca and juniper savannahs, and tobosa flats. Alkali sacaton and species of saltbush (*Atriplex*) occur on saline soils. Characteristic species of the plateaus and canyons are chino grama (*Bouteloua breviseta*), leatherstem (*Jatropha dioica* var. *dioica*), ocotillo (*Fouquieria splendens*), candelilla (*Euphorbia antisyphilitica*), lechuguilla (*Agave lecheguilla*), and sotols (*Dasylirion*).

The grass vegetation, especially on the higher mountain slopes, includes many southwestern and Rocky Mountain species not present elsewhere in Texas. Examples are Arizona fescue (*Festuca arizonica*) and mountain muhly (*Muhlenbergia montana*).

Under poor grazing management, rangeland sites become more xeric, and perennial grassland vegetation gives way to desert shrub and annual forbs and grasses. Creosotebush and tarbush complexes now cover some 15M ac of former desert grassland in the Trans-Pecos area. Tobosa draws, which once produced considerable forage, were invaded by burrograss and annuals as grazing pressure increased. Without the cover of perennial grass, the soils are subject to sheet and arroyo erosion from the intense summer thunderstorms.

More than 95% of the area remains as rangeland. Irrigated crops along the Rio Grande and other small drainages contribute to the economy. Cotton, alfalfa, sorghum, cantaloupe, sugar beets, grapes, and vegetables are grown. Most ranching operations are for livestock (cattle and sheep) production although management for mule deer, antelope, dove, and quail is important. Most livestock operations are cow-calf, and some stockers are carried over to use forages and irrigated fields.

Section 2.6 Eligible Brush Species Detrimental to Water Conservation

Target species for the WSEP are those noxious brush species that consume water to a degree that is detrimental to water conservation (i.e., phreatophytes). Control activities for these species are eligible for cost-share.

Eligible Species:

- mesquite (*Prosopis* spp.) – primarily honey mesquite (*P. glandulosa*)
- juniper (*Juniperus* spp.) – primarily Ashe juniper (*J. ashei*) or redberry juniper (*J. pinchotii*)
- saltcedar (*Tamarix* spp.)

Other species of interest, conditionally eligible for inclusion in the program:

- huisache (*Acacia farnesiana*)
- Carrizo cane (*Arundo donax*)

Rainwater et al. (2008) provides summary information on the potential for water yield enhancement via vegetative manipulations involving three specific plant groups: mesquite, juniper, and saltcedar. Each of the following three subsections (Rainwater et al. 2008) focuses on one of these groups while at the same time attempting to make comparisons between groups as appropriate. Research on mesquite, while not as prolific in terms of sheer numbers of studies, has probably been more comprehensive with respect to all of the plant's morphological and ecophysiological aspects. More research on various types of control mechanisms has been conducted on mesquite than on any of the other groups. The least research has been done with respect to water use by juniper, although geographic distribution of juniper is probably more extensive than either of the other groups. Research on saltcedar, as a plant that makes excessive use of water, is probably the most abundant. As it is critical to consider all factors when making predictions as to water use by specific plants or water savings resulting from their removal, the following selected statements from each of the species-specific subsections provide a reasonable summary of the current understanding for mesquite, juniper, and saltcedar.

Subsection 2.6.1 Mesquite

WATER USE BY MESQUITE

It has been estimated that a mesquite tree in Sonoran Desert washes would transpire 15 gpd (Nilsen et al. 1983). In another study by Ansley et al. (1998), they found that five years after mesquite density was reduced from 121 to 32 trees per acre, daily water use per tree increased from 13 to 44 gpd. By using sap flow techniques, Dugas and Mayeux (1991) determined the total seasonal water use of 1,600 L per mesquite tree, or 2.8 gpd based on a 150-day growing season. It is interesting to note that the reported value of 44 gpd water use by a single mesquite tree is far greater than the maximum tree-level daily water use of 32.2 gpd by saltcedar derived from sap flux measurement (Owens and Moore 2007). By tracking changes in water content in a 1.5-m soil profile and surface runoff over a period of seven years, Richardson et al. (1979) reported that following mesquite removal, ET was lower and soil moisture higher by 80 mm/yr, and runoff increased 30 mm/yr. In most Texas rangelands, most of the precipitation is retained in the upper 1 m of the soil profile where mesquite and herbaceous plants have similar root density (Weltz and Blackburn 1995), and there is little deep drainage. Therefore, water savings from removing mesquite cover from these rangelands would be minimal except in the riparian ecosystems.

DISTRIBUTION AND GROWTH HABITATS

Mesquite (*Prosopis* spp.) is a group of trees and shrubs that are widespread throughout the world. Mesquite is recognized as a rangeland invader in the southwestern United States. It has a wide distribution, from the semi-arid high plains of Texas to the Sonoran, Mojave, and Chihuahuan Deserts of the southwest United States. Depending on the growth habitats and local climate, mesquite can grow as a shrub or a tree. In the semi-arid grasslands of Texas where most precipitation occurs in the summer, and the water table is usually inaccessible, mesquite mostly relies on its lengthy shallow lateral roots to grow (Heitschmidt et al. 1988; Ansley et al. 1991), and it is more like a facultative phreatophyte (Thomas and Sosebee 1978).

In areas where most annual precipitation occurs as summer rainfall, deep drainage is unlikely to occur because immediate evaporation from soil surfaces reduces amounts of drainage, and also because of the changes in rooting patterns between woody and herbaceous species. Woody species such as mesquite tend to be more shallowly rooted in climates with summer rainfall regimes, as compared to more deeply rooted in climates with substantial winter precipitation (Schenk and Jackson 2002). Consequently, mesquite growing in the upland on Texas plains utilizes water from the unsaturated soil horizons. Dugas and Mayeux (1992) compared sap flow of mesquite from west Texas during the wet versus the dry season. They found that sap flow was 62% higher when soil was wet than dry, suggesting these plants rapidly utilized surface moisture when available.

In semi-arid west Texas rangelands with an annual precipitation of 450 mm, an argillic horizon has developed in the soil. The argillic horizon is rich in clay content (35-37%), which restricts the depth of water percolation. The wettest soil layers on these rangelands usually occur at depths of 60-75 cm during the growing season, and the water table is often more than 10 m deep. These impenetrable argillic horizons also restrict root growth. Therefore, the plants often have less developed tap roots. The majority of mesquite roots grow in the upper 60-cm soil profile, although 40% of roots were distributed below 67¬cm depths in regions with higher precipitation (Heitschmidt et al. 1988). In ecosystems where the water table is beyond exploitation of the deep roots, mesquite trees often respond rapidly to moisture in the upper soil layers with their extended shallow lateral roots (Easter and Sosebee 1975; Thomas and Sosebee 1978; Brown and Archer 1990; Wan and Sosebee 1991; Ansley et al. 1991). Lateral roots of mesquite can extend 30 ft or more from the tree center, and most of them are distributed 30 cm below the surface, a little deeper than grass roots (Ansley et al. 1991). Rapid water uptake by mesquite from the 60-cm soil profile following summer precipitation led to more than three times higher transpiration rates in the rainy season as compared to the dry season (Wan and Sosebee 1991). This condition suggests that mesquite lateral roots used rainwater very effectively. When lateral roots of mesquite were severed, the whole plant leaf area was reduced by 50% in the first growing season as compared to the non-severed plants (Ansley et al. 1991).

HOW MUCH WATER CAN A MESQUITE PLANT USE?

How much water can mesquite trees transpire? On upland sites at Vernon, Ansley et al. (1991) found that leaf transpiration rate on a sunny mid-summer day is about 227 g of water per leaf area (ft^2) per day. A typical 12 ft mesquite tree in a dense stand has about 130 ft^2 of leaf area. The calculated water use per day would come to 8 gpd per tree in a dense stand (200 trees per acre). The total water use per year by a mesquite stand represents 32% of annual precipitation (660 mm). When mesquite stand density declined to 120 trees per acre, water use per tree increased to 13 gpd, and annual water use per acre showed little change, as 31% of annual precipitation was used by mesquite. This finding is in sharp contrast to the water use pattern of saltcedar in a riparian ecosystem by Dahm et al. (2002), who showed annual ET over a saltcedar stand along the middle Rio Grande reach was 570 mm/yr; and the ET almost doubled in a much denser stand. Since the lateral roots of mesquite in west Texas rangelands can extend 30 ft from the tree center, the denser the stand, the less water was available to each individual tree, resulting in lower water use per tree (from 13 to 8 gpd).

WATER YIELD FROM MESQUITE CONTROL

In regions with strong hydrological sensitivity, removal of mesquite increased water yield. Rechenthin and Smith (1964) estimated that a comprehensive brush control program could save “12,000M m^3 of water in the Rio Grande Plains of Texas.” They assumed that removal of woody plants would reduce ET and increase grass production and water yield. However, their estimate was based on research conducted mainly in Arizona and California. In the Blackland Prairie of Texas (annual precipitation 860 mm/yr), heavy clay soils develop extensive cracking that allows deep drainage. By tracking changes in water content in a 1.5-m soil profile and surface runoff over a period of seven years, Richardson et al. (1979) reported that following mesquite removal, ET was lower and soil moisture higher by 80 mm/yr, and runoff increased 30 mm/yr. Surface runoff from these high-clay soils is substantial, averaging about 30% of the water budget.

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

- Evaporative demand is high, and typical herbaceous replacement vegetation uses most of the available soil water;
- Soils on these sites are typically deep, effectively isolating the groundwater zone from the surface;
- Runoff is generated primarily as Horton overland flow; and
- Runoff is very flashy in nature, generated by flood producing events, overwhelming other factors."

Subsection 2.6.2 Juniper

WATER USE BY JUNIPER

Juniper changes landscape water balances for a plant community by intercepting a significant proportion of precipitation with its dense canopy and litter (Young et al. 1984; Thurow 1991; Eddleman and Miller 1992; Hester 1996; Thurow and Hester 1997; Lyons et al. 2006; Owens et al. 2006). The interception loss associated with the canopies of redberry juniper (*J. pinchotii*) and Ashe juniper was 25.9% and 36.7% of gross precipitation, respectively (Hester 1996). Juniper is an evergreen, and therefore its canopy maintains a high interception potential throughout the year when compared to saltcedar or mesquite. Rainwater that passes through the canopy must also pass through the litter layer prior to entering the soil. The amount of interception loss associated with the litter layer is considerably greater for redberry juniper (40.1%) and Ashe juniper (43%) than for western juniper species (2-27%) (Young et al. 1984; Thurow and Hester 1997). As a result of interception loss via the canopy and litter, only 20.3% and 34% of annual rainfall reaches mineral soil under the canopy of Ashe juniper and redberry juniper, respectively.

Owens and Ansley (1997) conducted research at various sites in the Edwards Plateau of Texas, and found that daily water use by redberry juniper and Ashe juniper was 46.8 and 33.1 gpd, respectively. Dugas et al. (1998) estimated that removing woody plant cover reduced ET by 40 mm/yr for a period of at least two years. A study at the small-catchment scale by Huang et al. (2006) estimated that removal of juniper will increase streamflow by 46 mm/yr, representing about 5% of precipitation. A much higher water savings was reported in a study that was conducted at the AgriLife Research station in Sonora (Thurow and Hester 1997). The soils at their research sites were 6-18 in deep, which overlay a fractured limestone substrate. Their data indicate that substantial water yield can be achieved through conversion of pasture vegetation from juniper to grass dominance. Although the area received an annual precipitation of only 574 mm/yr, deep drainage occurred due to karst geology. The estimated deep drainage was 94 mm/yr in a 100% grass pasture as compared to 0 mm/yr in a juniper/oak/grass community. This difference was largely caused by a three-fold greater interception loss in the juniper/oak/grass community. The water yield following juniper removal is equivalent to 100,500 gal/ac/yr. There was little runoff from these pastures, because the cut juniper maintained very high infiltration rates after the trees were removed. The moderately grazed pastures also had a good herbaceous cover in the juniper interspaces. Therefore, the added precipitation reaching the soil as a result of reduced interception losses did not runoff of the pasture but was instead channeled into the soil.

DISTRIBUTION AND GROWTH HABITATS

The genus *Juniperus*, represented by 17 species in the western United States (Owens and Ansley 1997), has invaded many semi-arid rangelands. Junipers are among the most drought-tolerant of evergreens. When juniper trees invade a rangeland, herbaceous production is generally reduced; when the tree community matures, the herbaceous production is further diminished under closed canopies. This lack of herbaceous biomass reduces livestock production, wildlife diversity, and watershed protection. While juniper may grow over a broad range of habitat types, most juniper populations are found in the upland or non-riparian rangelands.

Juniper trees can strongly impact soil water content and landscape water balance of a plant community. The most direct negative impact is to use more water than the herbaceous vegetation they are replacing. Juniper trees have very large leaf area that transpires large quantities of water. The trees remain green all year long, and can transpire when other plants are dormant. Junipers have deep root systems. The trees proliferate in regions where deep drainage is available. *Juniper ashei* has wide distribution in the Edwards Plateau of central Texas where the geology is characterized as a karst system. Karst geology has two important features, namely, shallow soils, which cannot hold much water, and fractured parent material, which allows rapid, deep drainage of rainfall, and facilitates the presence of springs (Wilcox et al. 2006). These shallow soils are underlain with limestone containing deep fractures and underground caves and streams.

A study by McCole (2003), which was conducted on the Edwards Plateau of Texas, found that Ashe juniper trees derived 72-100% of their water from groundwater during dry periods of the year (late summer and winter). During the wet periods of the year (spring and fall), between 45-100% of water use by juniper was derived from soil water. This study indicates that juniper reduce groundwater resources both by lateral roots intercepting potential recharge during the wet season and direct uptake of groundwater by deep roots during the dry season. In another study, Leffler et al. (2002) found that Utah juniper (*J. osteosperma*) dried the soil from the surface downward to a depth of about 1 m. Because juniper uses large quantities of soil water, growth of herbaceous plants is suppressed under juniper overstory. Cutting juniper trees was effective in increasing total understory biomass, cover, and diversity; and herbaceous biomass was nine times greater in cut versus woodland treatments in the second year post-cutting (Bates et al. 2000).

Juniper also changes landscape water balances of a plant community by intercepting a significant proportion of precipitation with its dense canopy and litter (Young et al. 1984; Thurow 1991; Eddleman and Miller 1992; Hester 1996; Thurow and Hester 1997; Lyons et al. 2006; Owens et al. 2006). This intercepted rainfall results in high evaporation losses directly back to the atmosphere from wetted canopy and litter. This phenomenon has been estimated to reduce winter soil moisture recharge by more than 50% in dense juniper stands (Eddleman and Miller 1992). The interception loss associated with the canopies of redberry juniper (*J. pinchotii*) and Ashe juniper was 25.9% and 36.7% of gross precipitation, respectively (Hester 1996). Ashe juniper typically has a very dense canopy and thus more surface area to intercept rainfall, which is then evaporated to the atmosphere. Rainwater that passes through the canopy must also pass through the litter layer prior to entering the soil. The amount of interception loss associated with the litter layer is considerably greater for redberry juniper (40.1%) and Ashe juniper (43%) than for western juniper species (2-27%) (Young et al. 1984; Thurow and Hester 1997). As a result of interception loss via the canopy and litter, only 20.3%

and 34% of annual rainfall reaches mineral soil under the canopy of Ashe juniper and redberry juniper, respectively. In contrast, as high as 81.9% and 89.2% of annual precipitation reaches the soil under bunchgrass and shortgrass cover, respectively (Thurow and Hester 1997).

HOW MUCH WATER CAN A JUNIPER PLANT USE?

How much water can a single juniper tree use on daily basis? It depends on the tree size, annual precipitation, depth to water table, density of the stand, and environmental conditions. Generally, juniper trees transpire much more water than herbaceous vegetation because juniper transpires throughout the year, typically has more leaf area, and can access water at great depths. Owens and Ansley (1997) conducted research at various sites in the Edwards Plateau of Texas, and found that daily water use by redberry juniper and Ashe juniper was 46.8 and 33.1 gpd, respectively. With an average daily water use of 39.8 gal/tree, the juniper transpiration was equivalent to 400 mm/yr. Owens (1996) reported that more than 20-year old Ashe juniper transpired 33 gal per tree on a daily basis, which is close to that of Owens and Ansley (1997). Compared with other phreatophytes such as mesquite, juniper uses water twice as much on a per tree basis, and has lower water use efficiency. For example, redberry juniper daily water use was 46.8 gal/tree as compared to 20.9 gal/tree for honey mesquite (Owens and Ansley 1997), which was due to much larger leaf area of juniper. Using density estimates combined with a canopy model, Owens and Ansley (1997) predicted water use by juniper in a non-grazed pasture transpired an average of 1.4 ac-ft/yr (420 mm/yr), in a lightly browsed pasture transpired 0.97 ac-ft/yr, and in a heavily browsed pasture transpired 0.34 ac-ft/yr. It is logical that removal of juniper trees could lead to more water available for herbaceous plants and streamflow.

WATER YIELD FROM JUNIPER CONTROL

There is a potential for water savings by removing juniper. Wilcox et al. (2006) stated at the tree scale, for an area with an average annual precipitation of 750 mm, an individual tree will intercept and transpire virtually all of the available water. Therefore, the hypothetical potential water savings from removal of juniper would be substantial. Juniper cover can influence overland flow, streamflow, and/or groundwater recharge. There are, however, conflicting reports on the magnitude of the impact of juniper removal on rangeland hydrology.

Rangeland runoff dynamics are influenced by juniper cover. A widely held view is that overland flow and erosion will be increased by higher coverage of woody plants. Increases in runoff and erosion following juniper encroachment are the result of overgrazing of the diminishing herbaceous cover (Thurow and Hester 1997). Dugas et al. (1998) reported dramatic reductions in Horton overland flow following juniper eradication. On many juniper-dominated sites, tree canopy cover is between 20-35%, leaving up to 80% of the area with reduced vegetation or litter cover for protection (Miller et al. 2005). Frederick et al. (2007) reported 15 times higher runoff on juniper-dominated sites. Removal of juniper increased ground cover in the interspaces between trees from 16-36%, improved infiltration capacity, and reduced runoff by 67%. The effects of juniper woodlands on infiltration rates and erosion may be site-specific

(Blackburn and Skau 1974) and depend on slope, soil type, disturbance, vegetation cover, and frost dynamics (Wilcox 1994).

In contradiction to the widely held view, Blackburn (1975) found that infiltration through surface soil was actually higher in Ashe juniper areas than in grass-covered areas. The surface runoff should be higher following juniper removal. Wright et al. (1976) reported that Horton overland flow was significantly greater for two to three years following removal of juniper by burning; presumably it took this much time for the vegetation to completely recover. In the North Concho River watershed, Wu et al. (2007) found that when junipers were cleared on two sites, 7.7% and 10.7% of rainfall events produced runoff during the 2005-2007 study period. In a 4-year study in the Edwards Plateau, Huang et al. (2006) found that runoff made up 22% of the water budget, with baseflow from the spring accounting for about half of the total flow. The mean runoff after a rainfall event was 5.5 mm for the pre-treatment period and 8.8 mm for the post-treatment period, an increase of 60% after removal of juniper (Huang et al. 2006). Wilcox (2002) pointed out that effects of shrub control on surface runoff depend on how the control method modifies surface conditions. Therefore, shrub control could result in either an increase or decrease in Horton overland flow.

Water balance studies on the Edwards Plateau suggest that on average 15% of precipitation ends up as recharge for the underlying Edwards Aquifer, most of it via transmission losses from stream channels that cross the Edwards Aquifer recharge zone (Maclay 1995). Since juniper trees can access groundwater, it is reasonable to expect that removal of juniper trees would contribute to recharge of groundwater stores. ET estimation based on the Bowen ratio method at the juniper stand suggests the direct recharge in this landscape following juniper removal could be substantial (Dugas et al. 1998). They estimated that removing woody plant cover reduced ET by 40 mm/yr for a period of at least two years. A study at the small-catchment scale by Huang et al. (2006) estimated that removal of juniper will increase stream-flow by 46 mm/yr, representing about 5% of precipitation. From these limited studies, it appears that conversion of Ashe juniper woodlands to grasslands or open savannas will translate to increases in spring flow and groundwater recharge at the small-catchment scale.

Another important issue relating to water yield is how much juniper cover is removed. Bosch and Hewlett (1982) proposed that the amount of vegetation cover removed is proportional to changes in water yield and that, for many areas, removing less than 20% of the cover would not yield detectable changes in streamflows. This conclusion is understandable because, as Lyons et al. (2006) pointed out, when juniper cover increased from 20 to 100%, the amount of water lost to interception increased to 12.6 in/yr, or was 5.2 times higher. That amount was just interception by the canopy and the litter layer, which was then evaporated into the atmosphere; if transpiration was taken into account, there would be a huge difference in water consumption between 20 and 100% juniper cover. Thus, when juniper cover is reduced from 100 to 20%, there would hypothetically be a substantial water savings. However, Hibbert (1983) stated that the relationship between percentage of vegetation removal and reduced transpiration is non-linear, and that meaningful reductions in transpiration in arid environments are only achieved at high levels of removal. For instance, removing half of the deep-rooted vegetation may hypothetically result in only a 20% reduction in transpiration.

The fundamental controlling factor in determining water yield appears to be the availability of groundwater (Wilcox et al. 2006) as, for example, in riparian environments. For an upland site with a calcic soil horizon, such as in west Texas, the soil water is mainly in the upper 1 m of the profile, and downward flux of water is very small. In regions where junipers are found on deep soils, the subsurface flow does not occur. Eradication in these regions is unlikely to increase water yield or streamflow. For an upland area to be hydrologically sensitive to changes in woody plant cover, there must be a reservoir of water available to deep-rooted plants that is not available to shallow-rooted plants. In rangelands not characterized by groundwater within a few meters of the surface, the geological conditions must allow deep drainage to maintain these reservoirs. These areas are in the relatively mesic rangelands situated in karst geologic settings with shallow soils underlain by fractures of the parent material and underground caves where rapid recharge occurs after rainfall. There are reports of spring flow appearing or increasing after shrub control for juniper rangelands on the Edwards Plateau (Wright 1996) and for pinyon-juniper watersheds in Utah (McCarthy and Dobrowolski 1999).

Much higher water savings were reported in a study that was conducted at the AgriLife Research station at Sonora (Thurow and Hester 1997). The soils at the research sites were 6-18 in deep, which overlay a fractured limestone substrate. The data indicated that substantial water yield can be achieved through conversion of pasture vegetation from juniper to grass dominance. Although the area received an annual precipitation of only 574 mm/yr, deep drainage occurred due to karst geology. The estimated deep drainage was 94 mm/yr in a 100% grass pasture as compared to 0 mm/yr in a juniper/oak/grass community. This result was largely caused by a three-fold greater interception loss in the juniper/oak/grass community. The water yield following juniper removal was equivalent to 100,500 gal/ac/yr. There was little runoff from these pastures, because the cut juniper maintained very high infiltration rates after the trees were removed. The moderately grazed pastures also had a good herbaceous cover in the juniper interspaces. Therefore, the added precipitation reaching the soil as a result of reduced interception losses did not runoff of the pasture but was instead channeled into the soil.

Subsection 2.6.3 Saltcedar

WATER USE BY SALTCEDAR

It has been reported that saltcedar can use 200 gpd of water (Tribe 2002), but this number has been questioned by many researchers (Wilcox et al. 2006; Owens and Moore 2007). The literature cited by Owens and Moore (2007) indicated that daily water use of an individual saltcedar tree is in the range of 0.4 to 57 L, or less than 15 gpd (Davenport et al. 1982; Sala et al. 1996; Smith et al. 1996; Cleverly et al. 1997; Devitt et al. 1997a/b; Wullschleger et al. 2001; Nagler et al. 2003). A variety of techniques have been used to estimate water use by saltcedar at the stand scale. Dahm et al. (2002) found that saltcedar stands on floodplains had higher ET rates than those in non-flooding areas (1,000 vs. 750 mm/yr). In the Virgin River of southern Nevada, Devitt et al. (1998) reported ET for saltcedar stands of 750 mm/yr during a dry year and 1,500 mm/yr during a wet year. On the landscape scale, Culler et al. (1982) estimated that water consumption by saltcedar stands was about 1,090 mm/yr along the Gila River in Arizona. When the phreatophytes were removed, measurements revealed that water savings came to 480 mm/yr after the replacement vegetation was established. In the Middle Rio Grande, Cleverly et al. (2006a/b) found that a dense saltcedar stand frequently consumes up to 11.5 mm/day, especially when flooded. Conversion from a dense monoculture of saltcedar to a sparse saltcedar/saltgrass woodland was predicted to save 200 mm/yr (0.7 ac-ft/ac/yr), based upon both ET and leaf area index changes in such a conversion.

DISTRIBUTION AND GROWTH HABITATS

Saltcedar (*Tamarix* spp.) is an invasive weed that occupies vast areas in New Mexico, Arizona, California, Nevada, and Texas. Saltcedar species are exotic phreatophytes, with deep roots tapping the water tables, that depend on groundwater for their water supply (Anderson 1982). They grow mainly in riparian habitats, along stream channels and on floodplains. Saltcedar is capable of invading river banks and stream channels, replacing native phreatophytes and other native species, and forming solid dense stands. It is estimated that, in Texas alone, nearly a half million acres are infested by saltcedar (Knutson 2013).

Unlike native phreatophytes such as cottonwoods and willows, saltcedar species also have extensive shallow root systems. Saltcedar seedlings can grow a root system over 1 m deep in the first growing season and then grow up to 2 m by the end of the second growing season (Smith et al. 1997). Their roots easily develop from submerged or buried stems. The dual root systems enable saltcedar to use soil water wherever it is available, thus they are facultative phreatophytes, or opportunistic water users. Because of rapid root growth and dual root systems, saltcedar seedlings have competitive advantages in soil water uptake.

Saltcedar species are extravagant water users and compete successfully with the native phreatophytes for limited water supply. In the Rio Grande basin, for example, native cottonwoods are declining in most areas, and half of the wetlands in the drainage were lost in just 50 years. Invasion by non-native phreatophytic trees such as saltcedar and Russian olive

(*Elaeagnus angustifolia*) have dramatically altered riparian forest composition. Without changes in water management, exotic species will likely dominate riparian zones within half a century (Jackson et al. 2001).

When the water table drops below the root depths of the native obligate phreatophytes (e.g., cottonwoods, willows), these plants are severely stressed. For example, cottonwood prefers areas with groundwater less than 6.5 ft from the soil surface (Cleverly et al. 2006a). In contrast, saltcedar's primary taproot can easily penetrate 15 ft, or even grow down as deep as 40 to 50 ft (Tribe 2002; Wilson et al. 2004), or 75 ft (Morrison 2003). Once the taproot reaches the water table, secondary root branching becomes profuse (Di Tomaso 1998). Unlike obligate phreatophytes, such as cottonwoods and willows, saltcedar is often able to survive under conditions where groundwater is inaccessible (Devitt et al. 1997b; Di Tomaso 1998). Therefore, saltcedar water use is less affected by water table declines from drought or groundwater pumping due to its deeper rooting and effective use of summer rainfall by its shallow roots (Devitt et al. 1997a; Mounsif et al. 2002).

Water use by saltcedar trees has been a subject of debate. It has been reported that saltcedar can use 200 gpd (Tribe 2002), but this number has been questioned by researchers (Wilcox et al. 2006; Owens and Moore 2007). The large discrepancy in daily water use could be related to plant canopy size, plant age, depth to water table, and environmental conditions. Depending on the habitat and plant age, saltcedar can grow as a small shrub or a big tree.

Glenn and Nagler (2005) believe that the ecophysiological traits of saltcedar make it a formidable competitor of the native vegetation, and eventually the dominant species and largest water user in the riparian ecosystems.

HOW MUCH WATER CAN A SALTCEDAR PLANT USE?

Water use by saltcedar could vary greatly depending on growth habitats, soil moisture availability, and atmospheric demand. A variety of techniques have been used to estimate water use by saltcedar at the stand scale, including sap flow measurements, groundwater monitoring, large-lysimeter measurements, remote sensing, and micrometeorology. By using eddy covariance to estimate season-long ET along the middle Rio Grande, Dahm et al. (2002) found that saltcedar stands on floodplains had higher ET rates than those in non-flooding areas (1,000 vs. 750 mm/yr). In the Virgin River of southern Nevada, Devitt et al. (1998) reported ET for saltcedar stands of 750 mm/yr during a dry year and 1,500 mm/yr during a wet year.

Mature saltcedar plants are tolerant of a variety of stress conditions, including heat, cold, drought, flooding, and high salinity (Di Tomaso 1998; Smith et al. 1998; Glenn and Nagler 2005). These ecophysiological traits enable them to develop dense monocultures that replace native vegetation; as stand density and plant size increase, so does water use. Saltcedar accumulates salt in its leaf glands that is then transferred to the soil when plants drop their leaves. Increased soil salinity under saltcedar stands impairs germination and establishment of many native species. In the meantime, saltcedar seedlings can rapidly colonize moist areas after summer rains. Morrison (2003) observed that saltcedar can live in soils 25 times saltier than either willows or cottonwood can stand. It moves salt from the bottom of its 75-ft to 100-ft rooting depth to the soil surface. Over time, these accumulated salts may kill any other plants below or around it. It was reported that saltcedar can tolerate salt content of 8,000-10,000 ppm (Di Tomaso 1998; Nagler et al. 2006), which inhibits growth of competing species. Walker and Smith (1997) pointed out that the most single important way the invasion of saltcedar fundamentally alters ecosystems is through salinization of floodplain habitats. Therefore, they suggested that in many ecosystems being reclaimed from saltcedar invasion, only a return of annual floods, which leach the soil of salts, will allow the ecosystem to be re-vegetated with former dominants such as cottonwood and willow.

WATER YIELD FROM SALTCEDAR CONTROL

Water salvage estimates show a significant reduction in system water loss after saltcedar treatment (Culler et al. 1982; Weeks et al. 1987; Hays 2003; Bawazir et al. 2006; Groeneveld et al. 2006; Cleverly et al. 2006b). Clearing high density saltcedar stands has greater effect on water salvage than treating low density stands (Hays 2003). Hays (2003) did a paired analysis between herbicide treated and untreated plots in the Colorado River basin and found potential water savings of 400 mm/yr, based on the assumption of 49% mortality with top kill of saltcedar. From a before-after comparison, Groeneveld et al. (2006) estimated water savings of 3.1 ac-ft/ac on approximately 6,000 ac treated along the Pecos River, and the annual salvage came to 18,600 ac-ft. Bawazir et al. (2006) investigated water salvage by chemically controlling saltcedar at the Elephant Butte Delta of New Mexico, and found that estimated ET for non-treated saltcedar was 1,002 mm when compared to measured ET of 386 mm at the treated site, a difference of 61% for 189 days.

More realistic estimations on water salvage should be based on data collected after re-establishment of the native vegetation. On the landscape scale, Culler et al. (1982) estimated that water consumption by saltcedar stands was about 1,090 mm/yr along the Gila River in Arizona. When the phreatophytes were removed, subsequent measurements revealed that water savings came to 480 mm/yr after the replacement vegetation was established. In the Middle Rio Grande, Cleverly et al. (2006b) found that conversion from a dense monoculture of saltcedar to a sparse saltcedar/saltgrass woodland is predicted to save 200 mm/yr (0.7 ac-ft/ac-yr), based upon both ET and leaf area index changes in such a conversion.

Some field studies by the USGS indicated that measurable water salvage following saltcedar clearing is only 0 to 1.5 ac-ft/yr due to ET of replacement vegetation, increased evaporation, loss to groundwater, or other sinks (Culler et al. 1982; Weeks et al. 1987; Shafroth et al. 2005).

Preliminary results from a project in the Pecos River in Texas (Hart et al. 2004) indicate that there is a great potential for water salvage by saltcedar control. A study on the Pecos River by Sheng et al. (2007) conservatively estimates water salvage of 0.5-1.0 ac-ft per treated acre from control of saltcedar, and suggests that salvaged water most likely contributes to aquifer recharge rather than increased streamflow.

Subsection 2.6.4 Other Species of Interest

These other species of interest are conditionally eligible as target species for the WSEP.

HUISACHE

Huisache (*Acacia farnesiana*) is a perennial woody shrub that occurs throughout South Texas. In many areas it is a serious brush problem on rangelands, where it can occur either in pure stands or as a member of mixed-brush communities. Botanical surveys indicate that the species has become more widespread in geographical distribution over the last 150 years. There are several reasons why huisache is a successful invader of rangelands. The species produces abundant amounts of seed which has an impermeable seed coat, and can apparently persist for many years in the soil. Huisache seedlings have a tap root system that rapidly extends deeply into the soil soon after germination, assuring the seedling an adequate supply of water. Huisache plants, similar to honey mesquite, form a meristematic zone just below the soil surface during their first or second year of growth. Once this zone is established, the plants can resprout if the tops are mechanically removed or killed by fire. In addition, huisache roots are colonized by bacteria of the genus *Rhizobium*, which allows them to use atmospheric nitrogen gas as a nitrogen source. This provides the plants with a competitive advantage on nitrogen-deficient soils. Temperature and rainfall appear to limit the distribution of huisache. (Wood 2014)

CARRIZO CANE

Arundo donax, also called “giant reed” or Carrizo cane, is one of the largest size perennial grass species in the region. A colonial plant that grows in dense stands, it is found in many subtropical and warm-temperature areas of the world. It is thought to be originally native to eastern Asia, but the precise extent of its native distribution is unknown. Stands along the Upper Nueces River are the same genotype that grows on the Rio Grande, which originated from the Seville region of Spain. *A. donax* was introduced around the world as an ornamental/crop species, for erosion control, and for production of reeds. It has become invasive in many places throughout the world, primarily in riparian habitats. Where *A. donax* invades, it often forms dense stands. *A. donax* is a hydrophyte, achieving its greatest growth near water. However, it adapts to many different habitat conditions and soil types, and once established, is drought tolerant and able to grow in fairly dry conditions. It consumes prodigious amounts of water, as much as 2,000 L/m^2 per year of standing *A. donax*, to supply its incredible rate of growth. The plant’s thick fibrous root system enables *A. donax* to create large monocultures along stream banks and consume large quantities of water. It is also known that *A. donax* can transpire extremely large quantities of water, especially within stream channels where unlimited access to water fuels explosive growth. (Gary and Kromann 2013) Watts and Moore (2011) conclude that *A. donax* transpires at high rates similar to other riparian reeds resulting in high stand-level estimates of water use; annually, approximately 1,700 mm may be a reasonable estimation for *A. donax* stands in the Rio Grande watershed.

Section 2.7 Other Benefits of Brush Control Beyond Water Supply Enhancement

Torell, McDaniel, and Ochoa (2005) have noted that if brush control projects are to be profitable expenditures of public funds then the unmeasured benefits of ecosystem services to non-livestock entities must exceed the state, county, or federal cost-share necessary to induce livestock producers' participation in brush control projects.

Beyond enhancing water yield by conserving water lost to ET, recharging groundwater, and enhancing spring and stream flows, brush control provides other ecosystem services including the potential to:

- improve soil conservation and health,
- restore native habitat by improving rangeland with native grasses,
- improve livestock grazing distribution,
- aid in wildfire suppression through reduction of hazardous fuels,
- protect water quality and reduce soil erosion,
- improve and protect wildlife habitat, and
- manage invasive species.

The USDA-NRCS (2013) recognizes six purposes for undertaking brush management:

- Create the desired plant community consistent with the ecological site.
- Restore or release desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality or enhance stream flow.
- Maintain, modify, or enhance fish and wildlife habitat.
- Improve forage accessibility, quality and quantity for livestock and wildlife.
- Manage fuel loads to achieve desired conditions [to protect life and property from wildfire hazards]

WATER QUALITY

The relationship between water quality and the hydrologic nature of flow is readily apparent in waterbodies in the arid regions of Texas. The loss of discharge directly results in the concentration of pollutant loadings and the loss of critical aquatic habitat, affecting the State's ability to accomplish water quality goals. Historical hydrologic data has demonstrated a relationship between loss of perennial stream flows and the encroachment of woody brush. Brush control can restore aquatic habitat, improve water quality, and help achieve other beneficial uses of waterbodies and water quality goals. While the TSSWCB WSEP is targeted to watersheds based on priorities associated with water conservation needs and projected water yields, this program also supports the State's water quality goals and contributes to achieving the goals and objectives of the *Texas Nonpoint Source Management Program* and agency priorities for abating agricultural and silvicultural nonpoint sources of water pollution.

GROUNDWATER PROTECTION

Coordinating the state's groundwater protection efforts is the task assigned to the TGPC. The TGPC improves coordination between member agencies and works to protect groundwater as a vital resource. The TGPC implements the state's groundwater protection policy. The primary goals of the TGPC's Public Outreach and Education Subcommittee are to develop and implement educational outreach programs for landowners concerned with groundwater protection and environmental health issues and to facilitate interagency communication and coordination to provide support for landowner educational outreach projects. Activities include developing educational materials, coordination of outreach programs and special projects. The TSSWCB WSEP is a focus area for the Subcommittee in its efforts to implement the second edition of the *Groundwater Educational Outreach Plan*.

INVASIVE SPECIES

The Texas Invasive Species Coordinating Committee was established by the 81st Texas Legislature in 2009. The TISCC provides a forum for developing effective and timely interagency strategies and policies for invasive species control. The TISCC makes recommendations to the leadership of state agencies regarding research, technology transfer, and management actions related to invasive species control. A myriad of invasive plant and animal species, both aquatic and terrestrial, plague the water resources of Texas. Water quality is impaired, water quantity is diminished, and aquatic ecosystems are affected. For example, riparian areas infested by saltcedar (a non-native, invasive species) impact salinity levels in waterbodies. Saltcedar can also intensify water quality problems due to its ability to reduce groundwater supplies and streamflow through ET. Work by the TSSWCB WSEP supports the state's invasive species management goals and contributes to achieving the goals and objectives of the TISCC.

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Chapter 3 Priority Watersheds for Water Supply Enhancement

In 1985, TSSWCB and TWDB developed a list of water supply reservoirs where brush control could possibly enhance water supplies (Table 3.1) (TSSWCB 1999). The following criteria were used:

- Where surface reservoirs have vacant storage and can accept an increase in surface flow.
- Watershed of approximately 500 mi^2 or less and boundary conditions are minimized.
- A record of historical baseflow.
- Where brush clearing would progress upstream from a reservoir site.
- Where zero or minimal stream diversions occur.
- Where annual runoff averages more than 0.5 in and less than 5.0 in.
- Where rainfall is between 15 and 36 in per year.
- Where trees can remain along streams, and channelization is not necessary.
- Where state and federal regulations regarding wetland and pollution will not be violated.
- Where brush and/or phreatophyte infestation exceeds 20%.
- Where dissolution of near-surface salts is minimal and such areas can be identified.
- Where municipalities have water supply problems.
- Where the best historical data is available such as, streamflow and groundwater level.
- Where groundwater recharge and storage can be increased.
- Where hydrogeological conditions are favorable.
- Where the ratio of water use by brush/phreatophyte covered areas converted to grasslands or other vegetation is favorable. Also, where the ratio of the soil moisture with and without the brush is favorable to induce groundwater recharge.

Most areas historically considered under the above criteria could expect an increase in surface water flow. With respect to groundwater augmentation, however, the hydrogeological setting played an important role in the selection. For example, streams should traverse the recharge outcrops of aquifers; and if faulting exists, this would be even better.

Feasibility studies have since been conducted on several of the reservoirs included on this list.

Table 3.1 Water supply reservoirs where brush control could enhance supplies (TSSWCB 1999)

#	County	Water Supply	Waterbody	User	Comments
33	Montague	Amon Carter	Sandy Creek	Bowie	
16	Erath	Bailey's Lake	Kickapoo Creek	Lipan	
5	Blanco	Blanco River	Blanco River	Blanco	
7	Bosque	Bosque River	Bosque River	Meridian	
8	Bosque	Bosque River	Bosque River	Clifton	Proposed reservoir
40	Real	Camp Wood Creek	Camp Wood Creek	Camp Wood	
28	Kendall	City Lake	Cibolo Creek	Boerne	
30	Mills	City Lake	Colorado River	Goldthwaite	
20	Goliad	Coleto Creek	Coleto Creek	GBRA	Power cooling lake
52	Victoria	Coleto Creek	Coleto Creek	GBRA	Cooling reservoir
26	Jones	Ft. Phantom Hill	Elm Creek	Abilene	
46	Stephens	Hubbard Creek	Hubbard Creek	W. Central Texas MWD	
6	Blanco	Johnson City Lake	Pedernales River	Johnson City	Lake part of Pedernales River
47	Taylor	Lake Abilene	Elm Creek	Abilene	
24	Jim Wells	Lake Alice	Chiltipin Creek	Alice	
2	Archer	Lake Arrowhead	Little Wichita River	Wichita Falls	
13	Clay	Lake Arrowhead	Little Wichita River	Wichita Falls	
11	Callahan	Lake Baird	Mexia Creek	Baird	
42	Runnels	Lake Ballinger	Valley Creek	Ballinger	
9	Brown	Lake Brownwood	Pecan Bayou	Brownwood WCID	Irrigation and municipal supply
15	Eastland	Lake Cisco	Sandy Creek	Cisco	
25	Johnson	Lake Cleburne	Nolan River	Cleburne	
12	Callahan	Lake Clyde	N. Prong Pecan Bayou	Clyde	
14	Coleman	Lake Coleman	Jim Ned Creek	Coleman	
31	Mitchell	Lake Colorado City	Morgan Creek	Colorado City	
45	Stephens	Lake Daniel	Gonzales creek	Breckenridge	Base flow decline
10	Burnet	Lake Georgetown	N. Fork San Gabriel	BRA	
53	Williamson	Lake Georgetown	N. Fork san Gabriel	BRA	
55	Young	Lake Graham	Salt Creek	Graham	
23	Jack	Lake Jacksboro	Lost Creek	Jacksboro	
27	Kimble	Lake Junction	Llano River	Junction	
1	Archer	Lake Kickapoo	N. Fork Little Wichita	Wichita Falls	
48	Taylor	Lake Kirby	Cedar Creek	Abilene	
49	Taylor	Lake Lylte	Lylte Creek	Abilene	
18	Falls	Lake Marlin	Big Sandy Creek	Marlin	
3	Bandera	Lake Medina	Medina River	Medina Irrg. Co.	
37	Palo Pinto	Lake Mingus	Gibson Creek	Mingus	
32	Montague	Lake Nocona	Farmers Creek	Nocona	
54	Young	Lake Olney		Olney	
19	Falls	Lake Rosebud		Rosebud	
22	Haskell	Lake Stanford	Paint Creek		
35	Nolan	Lake Sweetwater	Bitter Creek	Sweetwater	
34	Nolan	Lake Trammel	Sweetwater Creek	Sweetwater	
39	Parker	Lake Weatherford	Clear Fork Trinity	Weatherford	
56	Young	Lake Whiskey Creek	Whiskey Creek	Newcastle	
41	Runnels	Lake Winters	Elm Creek	Winters	
21	Hamilton	Leon River	Leon River	Hamilton	Above Proctor
50	Uvalde	Leona River	Leona River		Increase base flow
29	Llano	Llano/City Lake	Llano River	Llano	
43	Shackelford	McCarty Lake	Salt Prong Hubbard Creek	Albany	
4	Baylor	Millers Creek	Millers Creek	N. Central Texas MWA	Not more than 20% canopy
36	Palo Pinto	Palo Pinto	Palo Pinto Creek	Palo Pinto MWD	
44	Somerville	Paluxy River	Paluxy River		
51	Val Verde	San Felipe	San Felipe Creek	Del Rio	San Felipe springs
17	Erath	Thurber Lake	Gibson Creek	Thurber	
38	Palo Pinto	Tucker Lake	Russell Creek	Strawn	
57	Zavala	Upper Nueces	Nueces River		Irrigation

GENERAL BRUSH CONTROL AREA

The amount of precipitation is a key factor to determine whether water yield can be achieved from brush removal. Through a literature review, Bosch and Hewlett (1982) found no increases in water yield in areas averaging less than 17.7 in/yr of annual precipitation. Hibbert (1979) stated if brush management is expected to increase water supply for an area, the annual precipitation should be greater than 18 in/yr. Wilcox (2002) also stressed that there is little prospect of increasing streamflows where mean annual precipitation is less than 19.7 in/yr.

The most widely used spatial climate datasets in the United States are those developed by Oregon State University's PRISM Climate Group, named for the PRISM climate mapping system. PRISM products are the official spatial climate datasets of the USDA, and are used by thousands of agencies, universities, and companies worldwide.

The general area eligible for feasibility studies statewide is based on the location of infestations of mesquite, juniper, saltcedar, huisache, and Carrizo cane. Areas in Texas with infestations of these species located between the 16-inch isohyet and the 36-inch isohyet may be considered for feasibility studies (Figure 3.1). This map uses 30-year average annual precipitation datasets from 1981-2010 (PRISM Climate Group, Oregon State University). Proposed feasibility studies for watersheds located outside of this area may be reviewed by the TSSWCB on a case-by-case basis.

Figure 3.1. Map showing the 16- to 36-inch average annual precipitation area of Texas, 1981-2010.

Section 3.1 Completed Feasibility Studies and Project Watersheds

Beginning in 1998, TSSWCB, in cooperation with many partnering entities, has been conducting assessments of the feasibility of conducting brush control for water supply enhancement in watersheds across Texas. These feasibility studies estimate the potential water yield enhanced.

For a watershed to be considered eligible for allocation of WSEP cost-share funds, a feasibility study must demonstrate increases in projected post-treatment water yield as compared to the pre-treatment conditions.

Feasibility Studies have been conducted and published, and the reports accepted by the TSSWCB as established WSEP Project Watersheds:

- Lake Arrowhead (RRA 2002)
- Lake Brownwood (LCRA 2002)
- Upper Guadalupe River above Canyon Lake (Bumgarner and Thompson 2012)
- Gonzales County [Carrizo-Wilcox Aquifer Recharge Zone and Guadalupe River] (McLendon et al. 2012)
- Frio River above Choke Canyon Reservoir (HDR 2000b)
- Nueces River above Lake Corpus Christi [above confluence Frio River] (HDR 2000c)
- Edwards Aquifer Recharge Zone [Frio River, Hondo Creek, Medina River, Upper Nueces River, Sabinal River, and Seco Creek] (HDR 2000a)
- North Concho River [O.C. Fisher Lake] (UCRA 1999)
- O.H. Ivie Reservoir [Upper Colorado River] (UCRA 2000)
- Wichita River above Lake Kemp (RRA 2000)
- Canadian River above Lake Meredith (CRMWA 2000)
- Palo Pinto Reservoir (BRA 2003b)
- Fort Phantom Hill Reservoir (BRA 2003a)
- E.V. Spence Reservoir [Upper Colorado River] (UCRA 2000)
- Lake J.B. Thomas [Upper Colorado River] (UCRA 2000)
- Pedernales River [Lake Travis] (LCRA 2000)
- Twin Buttes Reservoir [including Lake Nasworthy] (UCRA 2000)

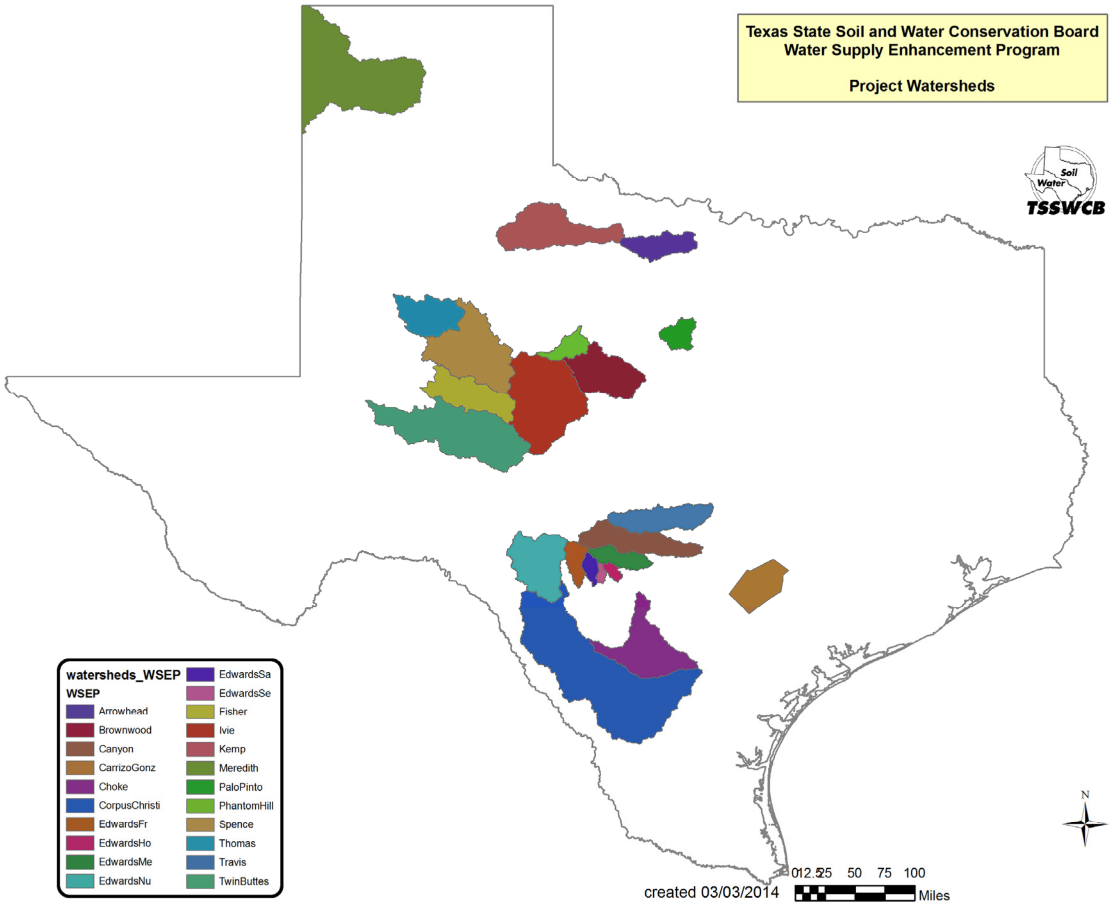

Figure 3.1.1 Map of Project Watersheds

Chapter 3.2 Feasibility Studies In Progress

Several feasibility studies are in progress. Once these studies are completed, if they demonstrate increases in projected post-treatment water yield as compared to the pre-treatment conditions, the TSSWCB may consider accepting the feasibility studies and establishing these areas as WSEP Project Watersheds.

Feasibility Studies In Progress, being conducted either solely with TSSWCB WSEP funding or collaboratively funded by third-parties:

- Goliad and Victoria Counties, including lower San Antonio and Guadalupe Rivers
- Lake Alan Henry (impounds South Fork Double Mountain Fork Brazos River)
- O.H. Ivie Reservoir lake basin (saltcedar specific)
- Upper Llano River, including South and North Llano Rivers and Junction City Lake
- Wilson, Karnes, and Refugio Counties (third-party funding; SARA)
- Edwards Aquifer Recharge Zone – Upper Nueces River (Carrizo cane specific) (third-party funding; NRA and EAA) [not shown on map]

The following are not feasibility studies, per se; rather, these studies are critical to the WSEP and will contribute to the overall understanding of water supply enhancement through brush control:

- Linking the Gonzales County Feasibility Study to the Carrizo-Wilcox Aquifer Groundwater Availability Model in Gonzales County
- Linking Empirical Data from Honey Creek State Natural Area to the Upper Guadalupe River Feasibility Study Model
- Effects of Huisache Removal on ET in South Central Texas at the McFaddin Ranch in Victoria County [not shown on map]

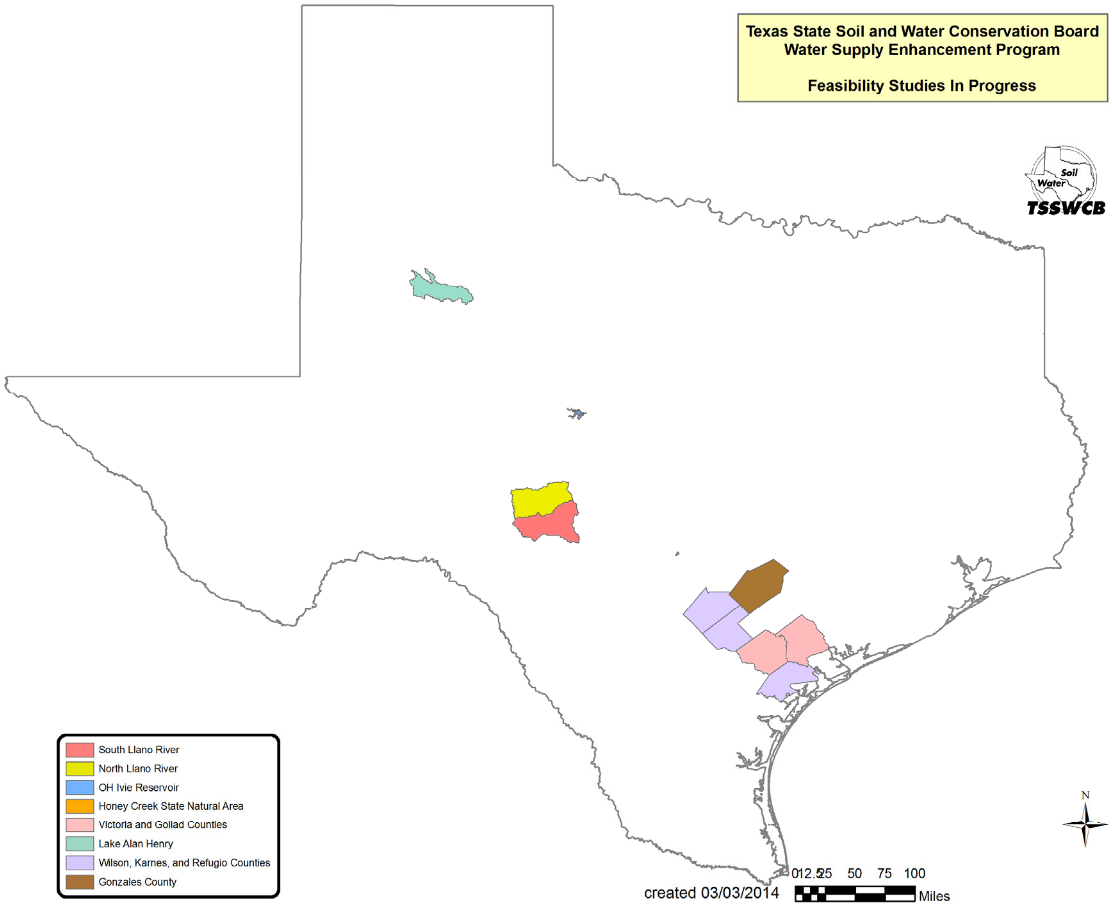

Figure 3.2.1 Map of Feasibility Studies In Progress

Chapter 3.3 Proposed Feasibility Studies

Local sponsors across the state have either applied for WSEP funding to conduct new feasibility studies or informally proposed new feasibility studies. As funds are appropriated by the Legislature, and at the recommendation of the Science Advisory Committee, the TSSWCB may consider allocating WSEP funds to complete any of these proposed feasibility studies for watersheds that do not have an acceptable study.

Proposed Feasibility Studies to be considered in the future:

- Bandera County groundwater recharge to Medina River
- DeWitt County, including lower Guadalupe River and Lavaca River
- Hubbard Creek Lake (saltcedar specific)
- Stillhouse Hollow Reservoir (impounds Lampasas River)
- Upper Brazos River Basin above Possum Kingdom Reservoir (endangered species issues)
- Caldwell and Guadalupe Counties, Carrizo-Wilcox Aquifer Recharge Zone
- Upper Blanco River, Edwards Aquifer Recharge Zone
- Upper Cibolo Creek, Edwards Aquifer Recharge Zone
- Lake Buchanan, including San Saba River, Brady Creek, and lower Pecan Bayou
- Lake LBJ, primarily Llano River below confluence of South and North Llano Rivers
- Lake Whitney, including Steele Creek
- White River Reservoir (saltcedar specific) [not shown on map]

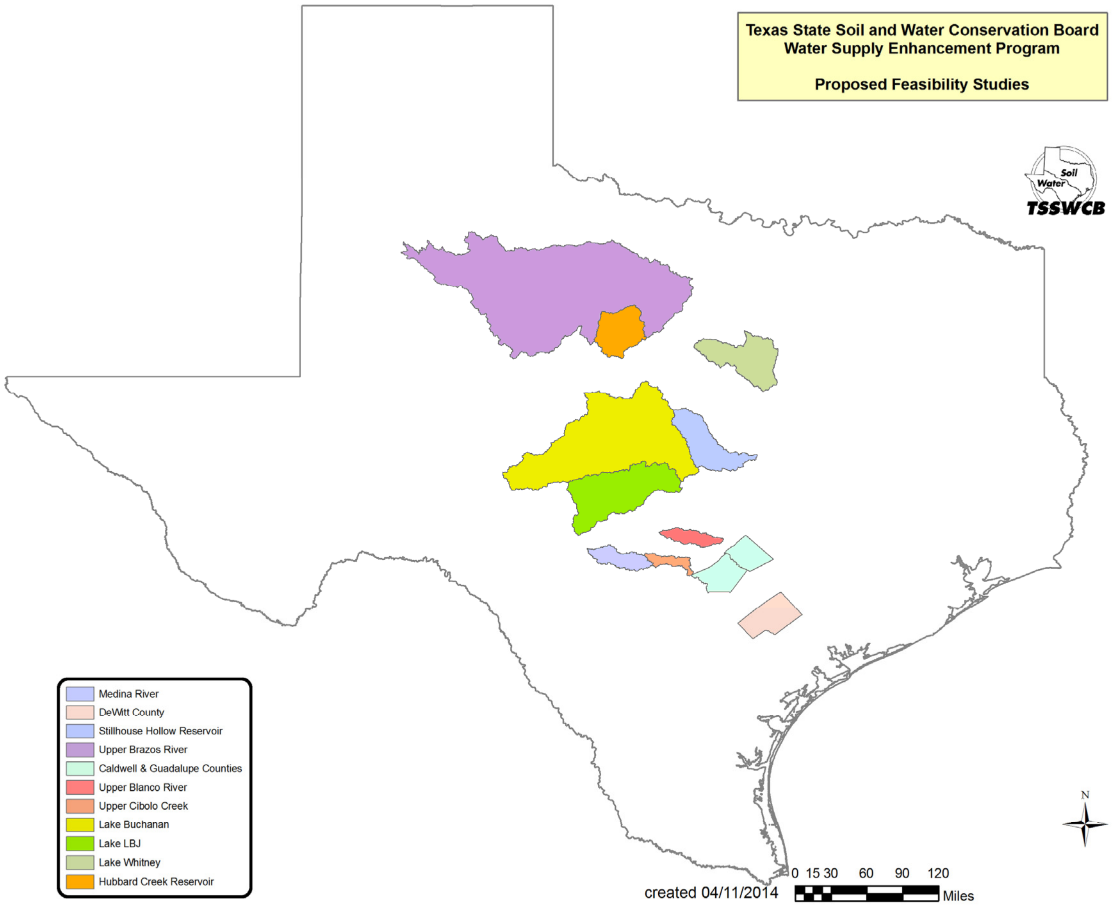

Figure 3.3.1 Map of Proposed Feasibility Studies

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Chapter 4 Program Goals and Evaluation Criteria

The primary focus of the Sunset review was on accountability for state-funded grant programs administered by the agency. HB1808 required that for each state-funded grant program, goals had to be established along with evaluation criteria, compliance monitoring, and methods for analysis. Program goals, as recommended by the Stakeholder Committee on February 22, 2012, were adopted by TSSWCB Policy on March 6, 2013 and describe the intended use of a water supply enhanced by the program and the populations that the program will benefit. The two specific goals are directly related to the Ranking Index and the geospatial analysis.

GENERAL GOALS

- Enhance domestic and municipal uses, including water for sustaining human life and the life of domestic animals, agricultural and industrial uses (which means processes designed to convert materials of a lower order of value into forms having greater usability), commercial value, and environmental flows.

- Enhance mining and recovery of minerals, power generation, navigation, recreation and pleasure, and other beneficial uses.

SPECIFIC PROGRAM GOALS

- Implement project proposals that most enhance water quantity to the municipal water supplies most in need.

- Direct program grant funds toward acreage within an established project that will yield the most water.

Section 4.1 Specific Goal 1

Specific Goal

- Implement project proposals that most enhance water quantity to the municipal water supplies most in need.

Evaluation Criteria

- Public water supplies expected to be benefited by the project
- Water supply yield enhancement to target water supplies, which is the projected water yield from a feasibility study
- WUGs relying on water supplies
- Percent of target water supplies used by WUGs
- Population of WUGs
- A calculated Ranking Index that gives a measure of the yield benefit per capita for each project proposal

Compliance Monitoring

- Performance certifications are carried out to verify initial treatment, and status reviews are performed to verify compliance with follow-up treatment requirements that specify the brush canopy is being maintained at 5% or less (target species only) of what was established after initial treatment during the 10-year contract.

Analysis

- The feasibility studies provide simulated water yields; therefore, based on the project's progress (number of acres treated) at a given point in time the amount of water yielded can be estimated. Additionally, the results of status reviews provide the agency a measure of compliance with follow-up treatment that can be used to estimate continuing water yield benefits over the course of the 10-year contract with the participant. Acres not in compliance may be eliminated from water yield calculations. Finally, when available, water quantity monitoring data is analyzed to observe actual impacts on water supplies.

Publishing

- Program results are documented in the statutorily-required Annual Report and this State Plan.

Section 4.2 Specific Goal 2

Specific Goal

- Direct program grant funds toward acreage within an established project that will yield the most water.

Evaluation Criteria

- A geospatial analysis is used to rank zones within a project's overall watershed into categories of high, medium, and low potential to yield water; a not eligible category is also included. The evaluated characteristics include:
    - Soil Type
    - Slope
    - Brush Density
    - Proximity to waterbodies and other hydrologically sensitive areas
    - Proximity to watershed outlet

Compliance Monitoring

- Performance certifications, carried out to verify initial treatment, provide verification that the treated area is within a specified zone.

Analysis

- Treatment of acreage not within the scope of the contract is not reimbursed through the program.

Publishing

- Program results are documented in the statutorily-required Annual Report and this State Plan.

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Chapter 5 State Water Plan and Regional Water Planning Groups

The *State Water Plan* is developed through a process where local and regional stakeholders are tasked with developing consensus-based regional plans for how to meet water needs during times of drought. The Legislature established this water planning process in 1997. The 16 regional water planning groups (RWPGs) (see Figure 5.1) represent a variety of interests, including agriculture, industry, environment, public, municipalities, business, water districts, river authorities, water utilities, counties, GCDs, and power generation. Each RWPG is responsible for developing its own regional water plan for a 50-year planning horizon. RWPGs make decisions on quantifying current and projected water demands and supplies, identifying water surpluses and needs, and evaluating WMS to meet needs. The TWDB then develops a comprehensive *State Water Plan* compiled from information in the 16 regional water plans and other sources. While the *State Water Plan* incorporates information from the regional water plans, it is more than just the sum of the regional plans; the *State Water Plan* serves as a guide to state water policy and provides recommendations to the Legislature. (TWDB 2013)

In developing their regional water plans, after the RWPGs compare water demand and supply and complete needs analyses, the groups evaluated potentially feasible WMS to meet the needs for water within their regions. A WMS is a plan or a specific project to meet a need for additional water by a WUG, which can mean increasing the total water supply or maximizing an existing supply. Strategies can include development of new ground or surface water supplies; conservation; reuse; or less conventional methods like weather modification, brush control, and desalination.

To meet the needs for water during a repeat of the drought of record, RWPGs evaluated and recommended unique WMS resulting in a total, if implemented, of 9.0M ac-ft/yr of additional water supplies by 2060. The total capital cost of implementing all the WMS recommended by the RWPGs is $53B. This estimated capital cost of WMS implementation does not include annual costs such as operational and maintenance costs. (TWDB 2012)

A report prepared for the TWDB in 2000 (Research and Planning Consultants, Inc.) assessed brush control as a WMS and concluded that the selection of watersheds for brush management projects to produce additional water for specific water supply purposes should be considered by the RWPGs or a specific WUG.

An issue raised by several RWPGs and the TWDB is that brush control may not result in “firm” yield during times of drought. Specifically, in the *State Water Plan*, the TWDB concludes that since water produced by brush control during a drought when little rainfall occurs is difficult to quantify, it is not often recommended as a strategy to meet municipal needs. A recently published study (Asquith and Bumgarner 2014) conducted by the USGS with funding from the TSSWCB examined this issue. The study linked the Upper Guadalupe River SWAT model created for the Feasibility Study with the TCEQ-authorized version of the Guadalupe River Water Availability Model (WAM). WAMs are used in water rights permitting and in regional water planning. The study quantified brush management water yields during periods lacking abundant rainfall, defined as when Canyon Lake storage was below the 25th percentile. The USGS concluded that brush control in the watershed does increase lake levels during times of the lowest quartile precipitation, that is, during drought-like conditions. All of the brush management scenarios resulted in an increase on average to monthly water supply storage in Canyon Lake during the drought quartile through the SWAT-WAM linkage: 110 ac-ft (20% brush treated); 448 ac-ft (40% brush treated); 754 ac-ft (60% brush treated); 1,080 ac-ft (80% brush treated); and 1,090 ac-ft (100% brush treated). A similar on-going study being conducted by HDR, with funding from TSSWCB, is examining the effects of brush control on modeled available groundwater (MAG) by linking the Gonzales County Feasibility Study to the Carrizo-Wilcox Aquifer Groundwater Availability Model (GAM).

Brush control for water supply enhancement is addressed differently by the 16 RWPGs in their regional water plans making incorporation into the *State Water Plan* complex. This presents challenges in interpreting how brush control for water supply enhancement is assimilated in the *State Water Plan*. It is described as brush control or brush management, or land stewardship, or range management. It might be a recommended or alternative WMS which may have a quantified yield or a zero yield; the *2012 State Water Plan* identifies only two regions where brush control is a recommended strategy with a quantified yield. It also may be included in Policy Recommendations; the *State Water Plan* includes brush control as an Innovative Strategy and a Data Collection/Research need.

The *2012 State Water Plan* includes only two recommended WMS for brush control with quantified yields. For Region F, the brush control WMS for the City of San Angelo is projected to yield 8,362 ac-ft/yr at a total capital cost of $23,020,000. For Region J, the brush control WMS for Kerr County is projected to yield 10,500 ac-ft/yr at a total capital cost of $3,937,790. Both strategies show the same projected volumes in all planning decades between 2010 and 2060. By the 2060 planning horizon, together these two brush control WMS only contribute 0.2% (18,862 ac-ft/yr) to the total supply volume from all recommended WMS.

Agriculture Code §203.053, requires that in prioritizing water supply enhancement projects for funding, the TSSWCB shall consider the need for conservation of water resources within the territory of the project, based on the *State Water Plan* as adopted by the TWDB. Therefore, in prioritizing projects for funding, brush control for water supply enhancement must be viewed favorably by the RWPG where the proposed project is, as discussed in the *State Water Plan*. "Viewed favorably" may be either as a recommended or alternative WMS which may have either a quantified yield or a zero yield, or as a Policy Recommendation. Otherwise, an application to TSSWCB for WSEP funding is considered to not qualify for funding. Table 5.1 provides a summary of how brush control is treated in the 2011 regional water plans and the *2012 State Water Plan*.

More information on the *State Water Plan* and the regional water planning process is available at http://www.twdb.texas.gov/waterplanning/.

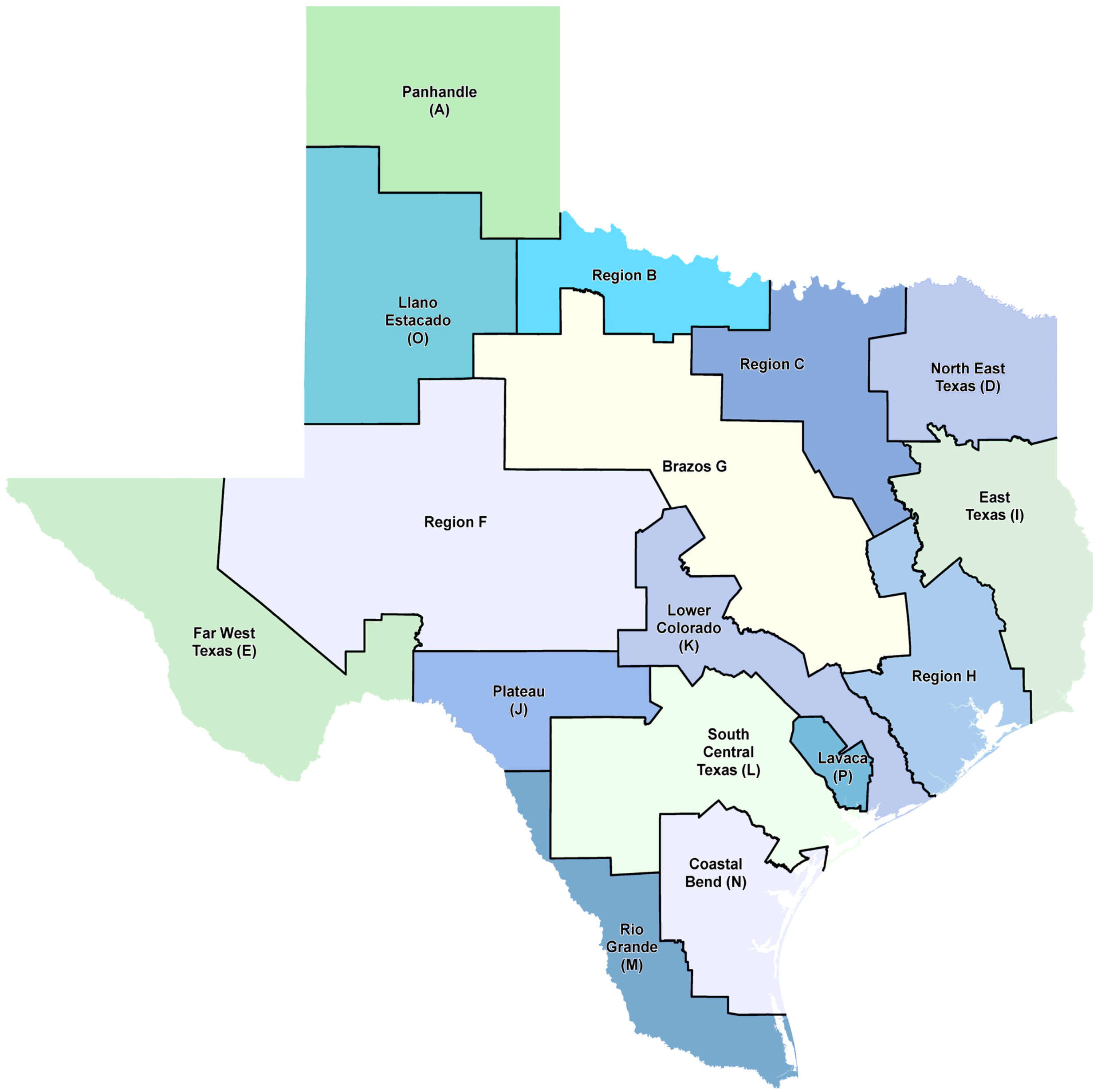

Figure 5.1 Regional Water Planning Areas (TWDB 2013)

Table 5.1 Summary of Brush Control in 2011 Regional Water Plans and 2012 State Water Plan (HDR 2013, as modified herein)

RWPG	TSSWCB WSEP Interest?	Brush control mentioned in RWP?	Brush control recommended in RWP?	Brush control fully evaluated and recommended as a WMS and included in DB12?	If not fully evaluated, how is it "recommended" by RWPG?	Other Comments
A	Y	Y	Y	N	Plan states this is an important component of the recommended WMS for water supplies. However, this WMS was not fully evaluated as part of the plan.	
B	Y	Y	Y	N	Brush control is mentioned in the land stewardship section of the plan as something that should be done if economically feasible.	
C	N	Y	N	N		The plan states that brush control is not an economically feasible option to meet water needs.
D	N	Y	N	N		The plan states that brush control is not an economically feasible option to meet water needs.
E	N	Y	Y	N	Plan states that this should be implemented for certain WCDs where it is economically feasible; however, the option was not fully evaluated as part of the plan.	
F	Y	Y	Y	Y		Recommended as a WMS for San Angelo with a quantifiable supply volume.
G	Y	Y	Y	N	Recommended in the text as a WMS for certain irrigation needs; however, volume and costs are not quantified.	
H	N	N	N	N		
I	N	Y	N	N		Brush control is not considered to be a cost effective strategy to meet water needs.
J	Y	Y	Y	Y		Recommended as a WMS in Kerr County with a quantifiable supply volume and further funding to continue to study the effectiveness of brush control programs.
K	Y	Y	Y	N	The plan promotes voluntary brush control and recommends that state and federal fund be made available for further studies.	

RWPG	TSSWCB WSEP Interest?	Brush control mentioned in RWP?	Brush control recommended in RWP?	Brush control fully evaluated and recommended as a WMS and included in DB12?	If not fully evaluated, how is it "recommended" by RWPG?	Other Comments
L	Y	Y	Y	N	The plan identifies brush control as an innovative strategy and makes a policy recommendation to encourage increased funding for brush control integrated with proven rangeland management practices.	Brush control was evaluated, but not recommended as a WMS in the plan.
M	Y	N	N	N		
N	Y	Y	N	N		Brush control was evaluated, but not recommended in the plan.
O	Y	Y	Y	N	Brush control is included in list of recommended WMS; however, it is not included in the database as the yield cannot be quantified.	
P	N	N	N	N		
16	10	13	9	2		

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Chapter 6 Annual Program Process

The TSSWCB collaborates with SWCDs, and other local, regional, state, and federal agencies to identify watersheds across the state where it is feasible to conduct brush control in order to enhance public water supplies. The agency has established detailed guidance on factors that must be considered in a feasibility study. Once a feasibility study is completed, if it demonstrates increases in projected post-treatment water yield as compared to the pre-treatment conditions, the TSSWCB may consider designating the studied area as a priority WSEP Project Watershed, making the watershed eligible for allocation of WSEP cost-share funds.

The TSSWCB uses a competitive grant process to rank and select feasible projects and allocate WSEP cost-share funds. Project proposals must relate to a water conservation need, based on information in the *State Water Plan* as adopted by the TWDB. A feasibility study must have been completed for the watershed in each proposal. Proposals are prioritized for each funding cycle, giving priority to projects that balance the most critical water conservation need of municipal WUGs with the highest projected water yield from brush control. Applications are ranked using a calculated Ranking Index that gives a measure of the projected water yield increased per capita user for each proposal. TSSWCB utilizes the Ranking Index and other statutorily-required considerations to prioritize proposals and allocate funding.

In project watersheds where WSEP cost-share funds have been allocated, the TSSWCB performs a geospatial analysis to delineate and prioritize the acreage eligible for cost-share of brush control activities. This geospatial analysis maximizes the positive impacts of brush control on water supply enhancement and the effective and efficient use of allocated funds by prioritizing the acreage that has the highest potential to yield water within the project watershed. Characteristics that are assessed in the geospatial analysis include soils, slope, brush type and density, proximity to waterbodies and other hydrologically sensitive areas, and proximity to the watershed outlet. The geospatial analysis results in four brush control priority zones for each watershed: high, medium, low, and not eligible.

In project watersheds where WSEP cost-share funds have been allocated, the TSSWCB works through SWCDs to deliver technical assistance to landowners in order to implement brush control activities for water supply enhancement. A 10-year resource management plan is developed for each property enrolled in the WSEP, in accordance with technical standards and specifications within the USDA-NRCS FOTG. These plans are designed to implement brush control, sound range management practices, and other soil and water conservation land improvement measures; these plans meet landowner goals and address wildlife considerations. These plans describe the extent and method of brush management to be implemented, follow-up treatment requirements, and brush density to be maintained after treatment.

Cost-share assistance is made available through the WSEP to eligible landowners as an incentive to implement brush control activities on eligible acres in project watersheds. The TSSWCB and the local SWCD enter into cost-share agreements with individual landowners.

Cost-share agreements must be based on an approved resource management plan developed for the property. Upon completion of brush control as described in the cost-share agreement, the local SWCD or TSSWCB inspects the work to verify the practice was performed and implemented in accordance with specifications set forth in the FOTG. Canopy cover of target brush species must be reduced to less than 5% to be certified. A performance certification is completed which then results in the cost-share payment being made by the TSSWCB to the participant.

All WSEP resource management plans that received cost-share assistance are subject to periodic status reviews conducted by the TSSWCB. Status reviews are conducted within three to five years after initial treatment of brush to determine if the canopy (target species only) is above 5%. A second status review is performed eight to nine years after initial treatment. If the producer is found out of compliance, they will not be eligible for another WSEP contract for a period of ten years.

A statutorily-required Annual Report is published by the TSSWCB to document WSEP results, assess the program, and report overall projected water yield enhanced. The number of acres of brush treated per project watershed using WSEP cost-share is reported. The enhanced water yield from the brush treated using cost-share is also reported. The number of status reviews conducted and number of contracts found to be out of compliance are also reported.

Section 6.1 State Plan Approval

Agriculture Code §203.051 requires the TSSWCB to prepare and adopt a state water supply enhancement plan.

Before the TSSWCB adopts the plan, the TSSWCB shall call and hold a hearing to consider a proposed plan. Not less than 30 days before the date the hearing is to be held, the TSSWCB shall mail written notice of the hearing to each SWCD. Written comments on the proposed plan are accepted. At the hearing, persons may present suggestions for any changes in the proposed plan.

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

2014 PROCESS

On May 15, 2014, the TSSWCB approved publishing notice in the *Texas Register* of the availability, for public review and comment, of the proposed revision to the *State Water Supply Enhancement Plan*. On June 6, 2014, notice was published in the *Texas Register*. The comment period on the draft *Plan* was open for 30 days, through July 7, 2014. An agency news release was also published.

On July 1, 2014, TSSWCB staff conducted a public hearing in Temple to receive oral comments on the draft *State Water Supply Enhancement Plan*. At the public hearing, the agency received a request to extend the comment deadline. As a result of the request, to ensure that all interested persons had an opportunity to provide constructive input on the development of the *Plan*, the Executive Director extended the comment period for an additional two weeks until July 21, 2014. Notice of the extended deadline was published in the July 11, 2014 issue of the *Texas Register*. An agency news release was also published.

The agency received 63 sets of comments from various citizens and entities on the draft *State Water Supply Enhancement Plan*. TSSWCB staff developed responses to comments received. Changes were made to the document as a result of comments received during the public comment period. A summary of public comments received and the State's responses is included as Appendix A.

On July 28, 2014, the TSSWCB adopted the *State Water Supply Enhancement Plan*, as proposed with changes made based on public comments received.

Section 6.2 Request for Proposals

For each funding cycle, the TSSWCB issues a *Request for Proposals for Water Supply Enhancement Projects* seeking program funding to conduct brush control under the WSEP. Proposed projects should focus on watersheds with a demonstrated water conservation need and where brush control has been shown, using a computer model, to be a feasible strategy to enhance surface and/or ground water supplies. A competitive proposal review process is used so that the most appropriate and effective projects are selected for funding.

Project proposals must relate to a water conservation need, based on information in the *State Water Plan* as adopted by the TWDB. Project proposals are evaluated giving priority to projects that balance the most critical water conservation need of municipal WUGs with the highest projected water yield from brush control.

WSEP funds will only be allocated to projects that have a completed feasibility study that includes a watershed-specific computer-modeled water yield component developed by a person with expertise as described in Agriculture Code §203.053(b). For a watershed to be considered eligible for cost-share funds, the feasibility study must demonstrate increases in post-treatment water yield as compared to the pre-treatment conditions.

The proposal submission packet includes the application for proposed water supply enhancement projects, a set of instructions that provides explanations of questions on the form and resources for answering those questions, and a set of guidelines that details project eligibility requirements and provides additional information critical for successful applications.

PROCESS FOR ACCEPTING AND RANKING WSEP PROJECTS

1. An application is submitted for consideration. A feasibility study is required. Proposals for cost-share funds that are associated with a watershed that does not have a feasibility study will be considered as an application for agency funding to complete the required study.

2. Applications are ranked according to the process developed by the Stakeholder Committee using a calculated Ranking Index.

3. Geospatial analysis is performed to identify zones of high, medium, and low potential water yield. Zones of high potential water yield are considered eligible acres within a project area. A not eligible zone is also identified.

Section 6.3 Project Establishment

Brush management will be accomplished through a series of watershed or sub-watershed projects in which brush management shows a strong potential to increase water yield.

The TSSWCB may delineate brush control areas in which a water need exists based on the most recent State Water Plan and in which brush control has a strong potential to increase water yield. Brush control area delineation will be based on feasibility studies, brush infestation, and water needs. SWCDs will manage individual projects. Within a brush control area, SWCDs may develop brush control projects where there is sufficient local support. Project proposals will be submitted to the TSSWCB for approval. After receiving a project proposal, the TSSWCB may conduct additional feasibility studies of the project area. A project that meets all requirements may then be approved by the TSSWCB. If there are more project proposals than can be supported by available cost-share funds, the TSSWCB will prioritize the projects, favoring the areas with the most critical water needs and the projects that will be most likely to produce substantial water yields and are cost-effective. The TSSWCB will approve brush control methods on the State level and the SWCDs will use the methods in developing individual landowner resource management plans. The TSSWCB, with the input of local SWCDs and landowners, will set cost-share rates for individual projects. SWCDs may contract with landowners to develop and implement individual resource management plans within project areas. Landowners may then implement resource management plans and receive cost-share payments upon completion of the brush control practices specified in the individual plans.

Section 6.4 Allocating Funds

Based on application ranking (using the Ranking Index) and the geospatial analysis, funds will be allocated to specific projects. An allocation is calculated based on the number of high ranking eligible acres, the desired number of eligible acres the proposal identifies for treatment, the average cost of brush control per method for each eligible acre, and the amount of time required to treat the number of acres targeted in the proposal. Funds will be allocated to projects in highest ranking order. Proposals may be partially funded if the allocation is at least 25% of the original request on the application.

Allocated funds may only be obligated to landowners for brush control 1) in the designated subwatershed, and 2) only in the high priority zone within that subwatershed as per the geospatial analysis. Allocated funds may not be obligated to landowners for brush control in 1) the medium or low zones within the designated subwatershed as per the geospatial analysis, or 2) other subwatersheds identified on the application or in the feasibility study.

On a date set by the Executive Director, each project's progress at obligating allocated cost-share funds to landowners shall be assessed. This assessment will be used to determine if unobligated funds should be de-allocated from a project and re-allocated to another project in order to maximize expenditure of WSEP funds during the fiscal year.

Section 6.5 Program Assessment

The number of acres of brush treated per project watershed using WSEP cost-share are reported in the WSEP Annual Report. Utilizing the modeled water yield for each subwatershed from the published Feasibility Studies, the enhanced water yield from the brush treated using cost-share is also reported in the WSEP Annual Report. Each Feasibility Study includes a target number of acres to be treated in each subwatershed which is compared to the running total of actual treated acres utilizing cost-share. This allows the approximate percentage toward project completion to be estimated, and thus the progress toward yielding the total predicted amount of water.

In accordance with TAC §517.36(b)(3)-(4), TSSWCB staff conduct status reviews on lands under contract to perform brush control activities and receive cost-share. Status reviews are conducted within 3-5 years after initial treatment of mesquite, mixed brush, juniper, or saltcedar to determine if the canopy (target species only) is above 5%. A second status review is performed 8-9 years after initial treatment. If the producer is found out of compliance with the 5% brush density, he will not be eligible for another WSEP contract for a period of ten years. The number of status reviews conducted and the number of contracts found to be out of compliance will be reported in the WSEP Annual Report.

The feasibility studies provide simulated water yields, therefore based on the project's progress (number of acres treated) at a given point in time the amount of water yielded can be estimated. Additionally, the results of status reviews provide the agency a measure of compliance with follow-up treatment that can be used to estimate continuing water yield benefits over the course of the ten-year contract with the participant. Acres not in compliance may be eliminated from water yield calculations.

Section 6.6 State Plan Revision

Agriculture Code §203.054 requires that at least every two years the TSSWCB shall review, and may amend, the *State Water Supply Enhancement Plan* to take into consideration changed conditions. Amendments to the plan shall be made in the manner provided for adopting the original plan.

Chapter 7 Project Establishment Process

PROJECT PROPOSALS, FEASIBILITY STUDIES, AND RANKING

A statutory requirement for the WSEP requires that there be a competitive aspect to the program so that all areas of the state would have an opportunity to propose a water supply enhancement project for local water supplies. In response, the agency developed an application and a process for entities to propose the establishment of projects.

A feasibility study, to include a computer model that estimates the potential water yield for the proposed project, is required to be completed prior to the project being established.

The feasibility study and the projected water yield are required so that the information can be used to rank proposals according to a set of criteria (i.e., the Ranking Index).

The ranking criteria were developed by the Stakeholder Committee. In addition to establishing criteria to rank proposals based on water yield and conservation needs, the agency has established a process to further refine implementation of the program within the scope of an established project. Through geospatial analysis, the agency will identify and target the acreage within project sub-basins that are most likely to result in the greatest water yield.

BRUSH CONTROL AREA DELINEATION

In order for a project to be eligible for State funding, it must be in a Project Watershed brush control area delineated by the TSSWCB. However, being in a Project Watershed brush control area does not guarantee that a project will be funded since the need for brush control funds is much greater than the available funding. The TSSWCB will delineate areas eligible for projects and cost-share funding where a water need exists based on the most recent State Water Plan (as adopted by the TWDB) and where brush control has a strong potential to increase water yield. Water yield potential is based on a completed feasibility study.

Because of the many factors involved in developing a successful project such as willingness of the local people to participate, landowner cooperation, social and economic considerations, and wildlife concerns, project applications should come from the local level.

Section 7.1 Applications for Funding

PROJECT DEVELOPMENT

Local SWCDs or other agencies in cooperation with SWCDs may develop project proposals within the State. The proposals will be submitted to the TSSWCB for its prioritization and approval. The TSSWCB, on its own initiative, may initiate project development in cooperation with local SWCDs.

SPONSORSHIP BY SOIL AND WATER CONSERVATION DISTRICTS

Local SWCDs, along with landowners, will be the key to the development of successful water supply enhancement projects. SWCDs have experience in the development and implementation of locally initiated projects. When local interest is such that action is deemed necessary, someone must lead and coordinate the effort. SWCDs are qualified to assume this role. They are accessible to anyone and they especially have considerable experience in working with landowners and land users, both individually and as a group. If a potential project area is larger than a single SWCD, several SWCDs may cooperate on the project development and implementation.

An SWCD may administer aspects of the WSEP within any Project Watershed located within the jurisdiction of that SWCD. The TSSWCB must prepare information on the WSEP and procedures for cost-sharing and provide this information to each SWCD. SWCDs may accept, review, and comment on individual applications for cost-share, and submit them to the TSSWCB for action. SWCDs may inspect and supervise projects within their jurisdictions. SWCDs, landowners, and other agencies will have the opportunity for input into all aspects of brush control projects.

REQUIREMENTS OF PROJECT PROPOSALS

1. A proposal must denote sufficient interest by a group of landowners and operators in a Project Watershed or a part of a Project Watershed designated by the TSSWCB to allow for the eventual completion of the project.
2. A valid proposal must show adequate sponsorship by one or more SWCDs. Enlisting additional sponsors, such as cities, counties, or other political subdivisions, could be beneficial to the project and is encouraged.
3. The SWCD involved must agree to take leadership and coordinate the project through implementation or agree to work with a regional conservation technician.
4. The project area proposed in the proposal should be of sufficient size to provide a significant potential gain in the water yield from the Project Watershed where the project is located.

5. The proposal should provide as much evidence as possible that the acreage to be treated within the project area does have the potential to improve water yields. Subjects that should be addressed are:
    (a) size and location of the area
    (b) brush – type, density, and canopy cover
    (c) water needs or potential needs
    (d) potential yield
    (e) wildlife compatibility to the project
    (f) landowner cooperation
    (g) ability of participants to pay their share of the cost
    (h) types of treatment measures
    (i) completion schedule
6. Proposals should be submitted as required by the TSSWCB.

The TSSWCB will provide assistance to SWCDs in the development of project proposals as needed.

Section 7.2 Feasibility Studies

As funding becomes available, feasibility studies will be used as a tool for delineating critical areas. These studies may be done in cooperation with other State agencies, universities, and local entities. These studies will be conducted in watersheds in the general brush control area (Figure 3.1) and where designated by the TSSWCB in consultation with SWCDs, other State and local agencies, and universities or as determined by the Texas Legislature. Feasibility studies may also be conducted by other entities and then submitted to the TSSWCB for consideration for project establishment.

At the recommendation of the Science Advisory Committee, funds may be allocated to complete a feasibility study for watersheds that do not have an acceptable study.

WSEP funds will only be allocated for brush control cost-share to projects that have a completed feasibility study that includes a site-specific computer-modeled water yield component developed by a person with expertise as described in Texas Agriculture Code §203.053(b).

For a watershed to be considered eligible for allocation of cost-share funds, the feasibility study must demonstrate increases in post-treatment water yield as compared to the pre-treatment conditions.

Feasibility studies must, at a minimum, have examined the following necessary input information to characterize the watershed under consideration for brush control:

- Watershed Delineation. The contributing drainage area that includes the treatment area should be identified using the USGS National Hydrography Dataset and the USGS Watershed Boundary Dataset (12-digit hydrologic units), and confirmed with a digital elevation model.
- Topography. Ten-meter digital elevation models from the USGS National Elevation Dataset should be used.
- Hydrology. Appropriate data from the USGS National Hydrography Dataset and analysis of the digital elevation model should confirm the locations of surface waterbodies, including stream and river channels, impoundments, and reservoirs within the area of interest, and other hydrologically sensitive areas critical to streamflow and aquifer recharge. Flood control dams (e.g., PL-566 floodwater retarding structures) must also be included in the hydrologic dataset.
- Soil Types and Distribution. The USDA Soil Survey Geographic database should be used to demonstrate the variations in soil type and other physical parameters that impact runoff and infiltration across the area of interest.
- Vegetation and Land Use. The USGS National Land Cover Dataset 2011 provides different land cover classifications at 30-m resolution which should be analyzed. Additionally, the Ecological Mapping System of Texas dataset published by the TPWD should be utilized in the analysis. For more recent land use descriptions as well as vegetation descriptions, digital orthophoto quarter quadrangles can be obtained from

the USDA and assembled as a mosaic to envelop the watershed of interest; 1-meter National Agriculture Imagery Program orthophotos from 2012 are available from the Texas Natural Resources Information System. Ground-truthing site visits are necessary to confirm vegetation types and locations.

- Roads and Highways. ESRI datasets include features such as streets, county roads, highways, freeways, and other transportation infrastructure that may affect local watershed behavior.

Proposals for cost-share funds that are associated with a watershed that does not have a feasibility study will be considered as an application for agency funding to complete the required study. Applications for funding to complete a new feasibility study will be referred to the Science Advisory Committee for review.

In considering the project's anticipated impact on water yield and in reviewing the applications for funding a feasibility study, the Science Advisory Committee will at least consider:

- Recommendations in the State Water Plan or a Regional Water Plan to conduct a feasibility study in the watershed of the proposed project.
- Published science that suggests the proposed project may yield water in Texas.

Once applications are considered, the Science Advisory Committee will direct applying entities to an appropriate modeler [per Texas Agriculture Code §203.057(a)] to conduct the feasibility study. If agency funds are allocated to complete a feasibility study, the TSSWCB may contract either with the entity who proposed the project, or directly with a qualified modeler chosen by both parties to conduct the feasibility study.

Subsection 7.2.1 Requirements for Computer Modeling for Water Yield Predictions

These requirements, developed by the Science Advisory Committee, provide detailed guidance for application of appropriate computer models for feasibility studies that predict water yield resulting from proposed brush control projects. For a proposed brush control project to be considered eligible for allocation of cost-share funds from TSSWCB, the feasibility study must demonstrate increases in post-treatment water yield as compared to the pre-treatment conditions. The projected water yield will be included in the WSEP proposal evaluation criteria and ranking system. These requirements provide the minimum criteria for the watershed description, model calibration and hydrologic data, and model simulations to accomplish this goal.

As required by Texas Agriculture Code §203.053(b) and §203.057(a), the feasibility study, and more specifically the computer modeling, must be conducted and developed by "a person with expertise in hydrology, water resources, or another technical area pertinent to the evaluation of water supply."

To balance WSEP consistency and comparability between feasibility studies with the practical limitation on how strictly prescriptive these requirements should be, it is recommended that for all new feasibility studies the Soil and Water Assessment Tool (SWAT) be used, or alternatively the Ecological DYnamics Simulation (EDYS) model. Justification for selecting a different model must be provided if either of the two recommended models is not utilized; in order to ensure that the selected model's capabilities are sufficient and that the model is employed properly, the adequacy of this justification will be reviewed by the Science Advisory Committee. All 12 of the original feasibility studies conducted by Texas A&M University in the early 2000s for the BCP utilized SWAT.

WATERSHED DESCRIPTION

The following list summarizes the input information necessary to characterize the watershed under consideration for brush control. All digital maps must be geo-referenced with sufficient metadata to allow overlays with other digital map layers.

- Watershed Delineation. The contributing drainage area that includes the treatment area should be identified using the USGS National Hydrography Dataset (NHD) and the USGS Watershed Boundary Dataset (12-digit hydrologic units), and confirmed with a digital elevation model (DEM).
- Topography. DEMs (10-meter) from the USGS National Elevation Dataset should be used and will likely require mosaic assembly to contain the watershed of interest.
- Hydrology. Appropriate data from the NHD and analysis of the DEM should confirm the locations of surface waterbodies, including stream and river channels, impoundments, and reservoirs within the watershed of interest, and other hydrologically sensitive areas

critical to streamflow and aquifer recharge. Flood control dams (e.g., PL-566 floodwater retarding structures) must also be included in the hydrologic dataset.

- Soil Types and Distribution. The USDA Soil Survey Geographic database (SSURGO) provides polygon-type maps that demonstrate the variations in soil type and other physical parameters that impact runoff and infiltration across the watershed of interest. These maps must also be joined in a mosaic form.
- Vegetation and Land Use. The USGS National Land Cover Dataset (NLCD) 2011 provides different land cover classifications at 30-m resolution which should be analyzed. Additionally, the Ecological Mapping System of Texas dataset published by the TPWD should be utilized in the analysis. For more recent land use descriptions as well as vegetation descriptions, digital orthophoto quarter quadrangles can be obtained from the USDA and assembled as a mosaic to envelop the watershed of interest; 1-meter National Agriculture Imagery Program orthophotos from 2012 are available from the Texas Natural Resources Information System. Ground-truthing site visits are necessary to confirm vegetation types and locations.
- Roads and Highways. ESRI datasets include features such as streets, county roads, highways, freeways, and other transportation infrastructure that may affect local watershed behavior.

MODEL CALIBRATION AND HYDROLOGIC DATA

Model calibration determines the degree to which a model represents a real-world system and establishes the usefulness of the model for evaluating factors affecting water yield and predicting changes in the water yield from brush control scenarios. Calibration is a systematic procedure of testing and tuning model input parameters that result in model predictions that best match a set of observational data. Calibration is completed through use of graphical and statistical methods to evaluate the degree to which the model corresponds to reality.

For WSEP consistency and comparability between feasibility studies, the period for calibration for all new feasibility studies is defined as 1995-2010.

Such models require historical daily rainfall data within, or at least near, the watershed of interest. These datasets can be collected from the National Climatic Data Center. Data from the defined calibration period should be collected to represent both wet and dry conditions. Other periods can be considered and may also be included if the range of observed rainfall conditions can be justified as being more representative of future conditions.

The model will need appropriate parameters to account for the abstractions that prevent part of the rainfall from reaching the stream and river channels as runoff. The selection of a simulation model and parameters must be based on an appropriate conceptual model that properly represents the conditions of the watershed. For example, the NRCS curve number method allows assignment of curve numbers based on soil type and condition, land use, and vegetation. The model's loss method must represent changes in runoff generation or streamflow caused by the removal of the target brush species. The parameter values must be supported by appropriate documentation, whether from field data collection, published values from the hydrologic literature, or the model's user guidance.

If the watershed of interest contains USGS streamflow gages, those flow data must be collected for comparison with the historical rainfall data and used in model calibration. Data from the defined calibration period should be sufficient to match the rainfall records. If the watershed of interest does not contain a USGS gage, data from either the nearest downstream gage or a gage in a neighboring watershed may be used to calibrate the model. The decision to use data from either a downstream gage or a gage in a neighboring watershed should be based on an analysis of the similarities in hydrology and land use to the watershed of interest.

The model should have a mathematical representation of spatially distributed infiltration losses. The model will also estimate ET of water from the root zone. The combination of the infiltration and ET amounts can be used as estimates of potential recharge to the shallowest aquifer in the watershed. These simulation methods must be clearly explained and their uncertainty estimated based on the model's user guidance and the hydrologic literature.

Optimally, rainfall and streamflow data from the complete defined calibration period will be available for calibration of the model over multiple seasonal variations. This situation would allow site-specific adjustment of the watershed parameters to best fit the observed rainfall-streamflow conditions. The calibrated model would represent pre-treatment conditions.

The modeler might have only local or nearby rainfall data for the defined calibration period and no observed streamflow data for calibration. In this situation, the most sensitive watershed characteristics must be identified, and ranges of reasonable values should be employed in multiple combinations to demonstrate a range of possible streamflow results with the pre-treatment conditions.

MODEL SIMULATIONS

After completion of the pre-treatment simulations, the model's watershed characterization input data must then be modified to represent the effects of brush control for water supply enhancement. The post-treatment simulations should employ the same rainfall data from the defined calibration period, and the post-treatment model results will demonstrate the impacts of brush control on surface water flows (and aquifer recharge) through comparison with observed or modeled pre-treatment flows. The primary indication of effectiveness on streamflow will be the total annual flow volume change per treated acre. The pre- and post-treatment losses to infiltration and ET can also be compared as at least qualitative contributions to groundwater recharge in terms of volume per treated acre.

Treatment scenarios for brush control to be simulated with the model must at least include the removal of 100% of treatable brush within the watershed of interest. Treatable brush is unique to each watershed and varies based on factors such as slope, brush density, proximity to waterbodies, and endangered species habitat. Factors that define treatable brush for the watershed of interest must be clearly described in the feasibility study.

As described in Texas Agriculture Code §203.053(c), TSSWCB shall define a standard method of reporting the projected water yield of each proposed project as modeled in a feasibility study. As such, projected water yield for the brush treatment scenarios for each sub-basin shall be reported in a feasibility study as the average annual gallons of water yielded per treated acre of brush, averaged over the simulation period used in the computer model.

Subsection 7.2.2 Models

SWAT

The Soil and Water Assessment Tool (SWAT) is a public domain model jointly developed over 25 years by USDA-ARS, USDA-NRCS, and AgriLife Research, part of The Texas A&M University System. SWAT is a small watershed to river basin-scale model developed to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. This dynamic and highly flexible computer model has over 1,700 articles in the peer-reviewed literature describing SWAT development, validation, and assessment (see https://www.card.iastate.edu/swat_articles/). SWAT is widely used in assessing soil erosion prevention and control, nonpoint source water pollution control, and regional management in watersheds. The model has been extensively validated with respect to land use change (138 peer reviewed articles) and specifically to brush control (Lemberg et al. 2002; Olenick et al. 2004; Afinowicz et al. 2005; Wang et al. 2010). (http://swat.tamu.edu/)

EDYS

The Ecological DYnamics Simulation (EDYS) model is a general ecosystem simulation model that is mechanistically-based and spatially-explicit. It simulates natural and anthropogenic-induced changes in hydrology, soil, plant, animal, and watershed components across landscapes, at spatial scales ranging from 1 m^2 or less to landscape levels (1,000 km^2 or larger). It is a dynamic model, simulating changes on an hourly (for aquatic) or daily (most terrestrial) basis, over periods ranging from months to centuries. EDYS has been has been linked with groundwater (MODFLOW) and surface runoff (GSSHA, CASC2D, HSPF) models. EDYS has been used for ecological evaluations, watershed management, land management decision making, environmental planning, and revegetation and restoration design analysis. Examples of land/water management scenarios that have been evaluated using EDYS include grazing, natural and prescribed burns, fire suppression, invasive plants eradication, drought assessment, water quantity, reclamation, restoration, revegetation, brush management. (Coldren et al. 2011)

Section 7.3 Ranking Applications and Requests for Feasibility Studies

COMPETITIVE GRANT PROCESS

A competitive grant process will be used to select projects and allocate funds for the fiscal year. Project proposals must relate to a water conservation need, based on information in the State Water Plan as adopted by the TWDB. A feasibility study must have been completed for the watershed in each project proposal. Project proposals will be prioritized for each funding cycle, giving priority to projects that balance the most critical water conservation need of municipal WUGs with the highest projected water yield from brush control. TSSWCB will issue a RFP that includes an application and describes the process for entities to propose projects. A two-year implementation plan must be submitted for each proposed project.

PROPOSAL EVALUATION CRITERIA AND RANKING

Funding for project proposals will be allocated through a competitive grant process that will rank applications based on projected water yield using evaluation criteria established by the Stakeholder Committee. Evaluation criteria include:

- Public water supplies expected to be benefited by the project
- Water supply yield enhancement to target municipal water supplies, which is the projected water yield from a feasibility study
- WUGs relying on the water supplies
- Percent of enhanced water supply used by WUGs
- Population of WUGs

A Ranking Index (RI) will be calculated that gives a measure of the water yield increased per capita user for each proposal:

- RI = Reliance on source * (Yield Benefit ÷ Population)
    - Yield Benefit per Population
        - Larger ac-ft/yr/capita increases RI
    - Reliance of a WUG on a specific water supply
        - Larger reliance increases RI
        - Reliance on source = percent of water being supplied from a specific source
        - Higher priority is given to those populations who rely solely on the specified water supply.

Being in a Project Watershed does not guarantee that a proposal will be funded since the need for brush control funds is much greater that the available funding. If more projects have been submitted than funds are available to support, the TSSWCB will prioritize the projects.

PROJECT PRIORITIZATION CRITERIA

The system that the TSSWCB uses to prioritize projects for each funding cycle gives priority to projects that balance the most critical water conservation need of municipal WUGs with the highest projected water yield from brush control. The specific criteria and factors that the TSSWCB considers in prioritizing projects for funding are detailed in 31 TAC §517.25, including:

- the need for conservation of water resources within the watershed based on the State Water Plan;
- the projected water yield of the project, based on soil, slope, land use, types and distribution of brush, and proximity of brush to rivers, streams, channels, and aquifer recharge features;
- any method the project may use to control brush;
- cost-sharing contract rates within the territory of the project (the WSEP rules [31 TAC §517.25(f)(3)] define a method for adjusting the Ranking Index for projects that propose a more favorable cost-sharing contract rate);
- the location and size of the project;
- the budget of the project and any associated requests for grant funds;
- the implementation schedule of the project;
- the administrative capacities of the TSSWCB and the SWCD that will manage the project;
- scientific research on the effects of brush removal on water supply; and
- any other criteria that the TSSWCB considers relevant to assure that the WSEP can be effectively, efficiently, and economically implemented.

PROCESS TO REVIEW APPLICATIONS FOR FUNDING NEW FEASIBILITY STUDIES

Applications for TSSWCB grant funding to complete new feasibility studies of conducting brush control for water supply enhancement will be referred to the Science Advisory Committee for review. The Science Advisory Committee will review the applications and make recommendations to the TSSWCB on which new feasibility studies should be conducted with agency funds.

In reviewing the applications and formulating recommendations, the Science Advisory Committee will consider the science-oriented questions below. In formulating recommendations for funding to the State Board, TSSWCB staff will consider recommendations from the Science Advisory Committee and the programmatic- and policy-oriented questions below.

1. Does the application indicate the proposed study will conform to the Requirements for Computer Modeling for Water Yield Predictions in Feasibility Studies? Does it appear that conformity can be reasonably achieved?
    - Does there appear to be sufficient streamflow and rainfall data for the watershed of the proposed project to satisfy the defined period for model calibration?

- Will the proposed study utilize either of the recommended models, or does the application provide adequate justification for selecting a different model?
- If the application indicates a modeler has already been selected by the applying entity, is the modeler a person with expertise in hydrology, water resources, or another technical area pertinent to the evaluation of water supply as required by Texas Agriculture Code §203.053(b) and §203.057(a)?

2. Is there an apparent "conflict of interest" between the modeler (performing entity and/or person) who will be conducting the computer modeling for the proposed study (including any entity providing matching funds) and any potential beneficiaries of the proposed project (i.e., WUGs, water providers/sellers)?

3. Are matching funds being provided to conduct the proposed study?
   - Are the matching funds ≥75% of project costs?
   - Are the matching funds ≥50% of project costs?

4. Is the budget for conducting the proposed study accurate and reasonable? Are appropriate costs budgeted? Is the timeframe for completing the proposed study reasonably expeditious?

5. What is the capacity and ability of the performing entity to fulfill all commitments specified in the application? Past performance by the entity on projects previously funded by TSSWCB is taken into account.

6. Is a need for conservation of water resources within the watershed of the proposed project documented in the State Water Plan (as adopted by the TWDB)?

7. Does the State Water Plan or a Regional Water Plan include a recommendation to conduct a feasibility study in the watershed of the proposed project?

8. What is the reliance per capita of the WUG on the PWS expected to be benefited by the proposed project (utilize method for Ranking Index from cost-share applications)?

9. Is the primary purpose of the proposed study an assessment of the feasibility of conducting brush control for water supply enhancement in a particular watershed?

10. Does the application include a statement of the anticipated impact on water resources as required by Texas Agriculture Code §203.057(c)?

11. Is the application's statement of the anticipated impact on water resources supported by published science that suggests the proposed project may yield water in Texas?
    - Was the published science conducted in the watershed of the proposed project?
    - Was the published science conducted in a similar watershed in Texas?
    - Was the published science conducted in a similar watershed outside of Texas?

12. Will the proposed study examine brush species identified as detrimental to water conservation in the State Water Supply Enhancement Plan?

13. Is the watershed of the proposed study identified in the State Water Supply Enhancement Plan as a priority for conducting a new feasibility study?
    - If not identified as a priority, was a feasibility study previously published for the watershed of the proposed study but for a different species of brush?
    - As a factor of holistic and synergistic watershed management, are other watershed planning and management activities ongoing in the watershed of the proposed study?

Once applications are considered, the Science Advisory Committee will direct applying entities to an appropriate modeler [per Texas Agriculture Code §203.057(a)] to conduct the new feasibility study.

Section 7.4 Prioritizing Acreage within a Project Area through Geospatial Analysis

Determination of the efficiencies with which controlling brush can yield additional water requires the evaluation of the properties of the geology, soil, flora, and topography unique to each watershed and their interactions with each other in response to climatic conditions. Other criteria to be considered for selecting sites for brush control are water cost and the potential impact on endangered or threatened species.

Numerous scientific studies conducted in Texas and across the U.S. have attempted to evaluate the impacts of brush on the water cycle and what potential water savings may be realized by controlling a given brush species. A focused approach that targets hydrologically sensitive areas of a watershed is thought to have the greatest potential for increasing water yield (increased streamflow or groundwater recharge) from a given watershed. Based on this premise, a multi-layered geospatial analysis is used by TSSWCB as a tool to prioritize areas of a selected watershed that, based on the criteria used, have the most potential for increased water yield resulting from brush control. This methodology was initially described for TSSWCB by Fish and Rainwater (2007).

This analysis will consider multiple landscape characteristics available for a selected watershed and will assign a ranking to all areas of the watershed based on the overall number of these characteristics that apply to a specific location.

In order to maximize the positive impacts of brush control on water supply enhancement and the effective and efficient use of allocated funds, a geospatial analysis will be performed to delineate and prioritize the acres eligible for cost-share that have the highest potential to yield water within the project watershed and thereby increase water supplies. Characteristics that will be assessed in the geospatial analysis include:

- Soil Type – relative to hydrologic properties such as runoff potential or recharge/infiltration rate
- Slope – sufficiently steep to affect runoff potential or infiltration rate but not impair method of brush control
- Brush Density – type and density of brush to be treated in fraction of the area with treatable brush
- Proximity to Waterbodies – including riparian areas and other hydrologically sensitive areas critical to streamflow and aquifer recharge
- Proximity to Watershed Outlet

The Science Advisory Committee will be consulted on the multiple criteria for each characteristic for each watershed. The geospatial analysis results in four brush control priority zones for each watershed: high, medium, low, and not eligible. Funds allocated to the sub-basin may only be obligated to landowners for brush control on acreage within the high priority zone.

When collectively considered, these factors will assign a priority to all areas of a selected watershed based on the total number of criteria that they meet. Areas of the selected watershed that exhibit the majority of these parameters will receive the highest ranking and those that have fewer characteristics will receive lower priority.

Due to the sensitive nature of the following areas, they are automatically excluded from the potential areas where brush control should occur.

- Areas that are designated as project habitat or endangered species habitat
- Slopes greater than 16%

The ranking system is based on site characteristics for each of the five factors and their impacts on the goal of a specific water supply enhancement project. Two ranking systems (Manage Brush for Aquifer Infiltration Enhancement and Manage Brush for Surface Water Enhancement) were developed according to the intended goal of the brush management effort. Areas of the watershed that receive the lowest value from this system will be the most feasible areas for improving water yield for their respective goal.

When planning a brush control effort, other factors must be considered in order to minimize potential negative impacts to the landscape, the receiving waterbody and downstream water users. Adhering to brush control guidelines set forth in the NRCS FOTG and this Plan will be project first steps in preventing negative impacts. Some potential negative impacts are:

- increased erosion and pollutant transport to the receiving waterbody as a result of poorly managed brush control practices
- brush control conducted too close (within 35 ft) to stream could cause increases in sediment and pollutant loading
- chosen method of brush control may harm project or sensitive habitat.

Chapter 8 Project Implementation

Section 8.1 Allocation of Grant Funding for Established Projects

PROCESS FOR ALLOCATING FUNDS TO ESTABLISHED PROJECTS

Based on application ranking and the geospatial analysis, funds will be allocated to specific projects. An allocation is calculated based on the number of high ranking eligible acres (from the geospatial analysis), the desired number of eligible acres the proposal identifies for treatment, the average cost of brush control per method for each eligible acre, and the amount of time required to treat the number of acres targeted in the proposal. Funds will be allocated to projects in highest ranking order. Proposals may be partially funded if the allocation is at least 25% of the original request on the application.

Allocated funds may only be obligated to landowners for brush control 1) in the designated subwatershed, and 2) only in the high priority zone within that subwatershed as per the geospatial analysis. Allocated funds may not be obligated to landowners for brush control in 1) the medium or low zones within the designated subwatershed as per the geospatial analysis, or 2) other subwatersheds identified on the application or in the feasibility study.

PROJECT ASSESSMENT AND POSSIBLE REALLOCATION OF FUNDS

On a date set by the Executive Director, each project's progress at obligating allocated cost-share funds to landowners shall be assessed. This assessment will be used to determine if unobligated funds should be de-allocated from a project and reallocated to another project in order to maximize expenditure of WSEP funds during the fiscal year.

If less than 50% of the original allocation is not yet obligated, and project partners do not have a reasonable expectation of obligating the remaining allocated funds, then funds may be de-allocated.

If funds are de-allocated, funds will be reallocated to 1) projects that received an original allocation which only partially funded the application, in order of original highest ranking, 2) projects that received an original allocation and have demonstrated progress at obligating cost-share funds and a need for additional cost-share funds, in order of original highest ranking, 3) conduct new feasibility studies, or 4) other projects that did not receive an original allocation in order of original highest ranking.

Section 8.2 Implementation

Voluntary land stewardship and the efforts of private landowners to control water-depleting brush are vitally important to the ecological health of productive rangelands across the state.

Once a project has been approved and funding made available, the responsible SWCD will begin implementation. The TSSWCB may provide agency grant funds to SWCDs in order to provide technical assistance to landowners for brush control and to administer the water supply enhancement cost-share program.

In order to maximize the effective and efficient use of WSEP grant funds, an SWCD participating in a water supply enhancement project must choose one of two options to provide technical assistance to landowners for brush control and to administer the cost-share program.

This policy provides a foundation for the TSSWCB in considering the administrative capacities of an entity that will manage a water supply enhancement project, as required by Texas Agriculture Code §203.053(d)(8) when prioritizing proposed projects.

OPTION A – COOPERATIVE AGREEMENT FOR REGIONAL CONSERVATION TECHNICIAN

The participating SWCD agrees to allow a regional conservation technician, funded by the TSSWCB through a different SWCD, to perform all duties and responsibilities associated with implementing a water supply enhancement project within the jurisdiction of the participating SWCD on behalf of the participating SWCD. The participating SWCD will cooperate with the regional conservation technician and TSSWCB staff to implement the water supply enhancement project. The participating SWCD will not be eligible for reimbursement of any costs associated with implementing the water supply enhancement project within the jurisdiction of the participating SWCD.

OPTION B – PARTICIPATING SWCD PROVIDES FOR TECHNICAL ASSISTANCE

If a participating SWCD chooses to administer the WSEP within the jurisdiction of that SWCD, as provided for by Texas Agriculture Code §203.101, then the participating SWCD agrees to employ a district conservation technician to perform all duties and responsibilities necessary to provide technical assistance and to administer the cost-share program within the jurisdiction of the participating SWCD. TSSWCB staff and regional conservation technicians will not perform any duties and responsibilities associated with the provision of technical assistance or administering the cost-share program, but will provide guidance and direction to the participating SWCD on WSEP rules, policies, and procedures.

The participating SWCD may be reimbursed by the TSSWCB for actual costs incurred associated with implementing the WSEP, up to 15% of the cost-share allocation for that water supply enhancement project.

Duties and responsibilities related to providing technical assistance and administering the cost-share program include, but are not limited to:

- Soliciting landowners to participate in a water supply enhancement project
- Developing water supply enhancement resource management plans for participating landowners
- Writing cost-share contracts for participating landowners
- Conducting performance certifications of brush control work completed
- Communicating with TSSWCB staff and regional conservation technicians on progress to implement the water supply enhancement project

Subsection 8.2.1 Water Supply Enhancement Plans for Landowners

The foundation of the WSEP is the 10-year resource management plans developed for and implemented by landowners on properties voluntarily enrolled in the Program. These conservation plans are based on the USDA-NRCS practice standards for brush management, prescribed grazing, and wildlife habitat management. The conservation delivery system is critical for this aspect of the WSEP; local SWCDs are responsible for developing and approving these landowner plans.

A water supply enhancement plan is a site-specific resource management plan for implementation of brush control, sound range management practices, and other soil and water conservation land improvement measures. It includes a record of the eligible person's decisions made during planning and the resource information needed for implementation and maintenance of the plan that has been reviewed and approved by the SWCD. A plan describes the brush control activities to be implemented, follow-up treatment requirements, and brush density to be maintained after treatment. These landowner conservation plans mitigate the impact of brush control on other natural resources. It includes appropriate land treatment practices, production practices, management measures, technologies or combinations thereof needed to achieve a level of brush control and management necessary to increase watershed yield, meet landowner goals, and address wildlife considerations.

A water supply enhancement plan must contain an implementation schedule. The implementation schedule, as far as is practicable, should balance the need for increasing water conservation with the needs of agricultural producers to have sufficient time to implement practices in an economically feasible manner. No other entity is more qualified to make this determination than a SWCD. This places tremendous responsibility on SWCDs, because these types of decisions require judgment and local knowledge.

During plan development, consideration must be given to local conditions and economy and must place appropriate importance on conserving water resources. Highest priority will be given to the implementation of the most cost effective and highest water yielding areas.

PLAN DEVELOPMENT

The responsible SWCDs will assist landowners with development of individual plans for brush management for the purposes of increasing watershed yield. The extent and methods of brush management included in each plan will be determined in accordance with specifications in the NRCS FOTG, as approved by the local SWCDs. Each plan will include implementation of sound grazing management following brush treatment. Based on these plans, the SWCD may enter into contracts with the landowners for cost-share of brush management.

The planning process outlined in the NRCS National Planning Procedures Handbook will be used to develop, implement, and evaluate water supply enhancement plans. The TSSWCB requires that water supply enhancement plans meet Resource Management System standards as defined in the NRCS FOTG for the conservation management units planned. In addition to these resources, the following guidelines should be followed.

ASSESSING BRUSH DENSITY

For the purpose of obtaining uniformity in determining brush density, all measurements will be made using the open crown intercept method. First, observe the site and select a uniform area that is representative of the site to be treated. Next, pace or measure the crown intercept along lines across, or in, the brush to be treated (mesquite and juniper). The percent of paces, or measurements, under the crown canopy of the brush in relation to the total number of paces or measurements will give the approximate percent of crown canopy of the brush. The distance and number of lines to pace to obtain a reasonably reliable sample will vary with the uniformity of the brush stand.

If the brush stand is uniform, two to four lines of 200 paces should give a suitable sample, or a single line all the way across the brush stand may be representative. Where the brush stand is not uniform or when the canopy is near the moderate or heavy canopy thresholds, more samples will typically be needed.

A record will be made of the percent crown canopy, and where sample measurements were taken. These records will be kept in the water supply enhancement plan.

ASSESSING BRUSH TYPE

Because average costs differ according to brush type, it is imperative that brush type is accurately assessed. If only one brush category is present, then perform canopy counts on a pasture basis. However, if multiple brush categories are present, then canopy counts should be completed on a NRCS ecological site basis. In order to do this, the planner must use NRCS soil surveys and ecological site descriptions to determine the different possible ecological sites and where they are located.

According to this assessment, to be classified as mesquite, the site must contain pure stands of mesquite or mixed mesquite, juniper and other species where the target species canopy is at least 10% and the juniper canopy is less than 5%.

To be classified as juniper, the site must contain pure stands of juniper or mixed juniper, mesquite and other species where the juniper is the dominant species and its canopy is at least 10%.

To be classified as mixed, the site must contain mixed juniper and mesquite where juniper is not the dominant species but: (1) the juniper canopy exceeds 10%, or (2) when the juniper canopy is 5-10%, then juniper must comprise at least 33% of the total canopy cover.

ESTABLISHMENT OF PRACTICE STANDARDS

The criteria for the resource management plans are defined by the TSSWCB to be the practice standards issued by the USDA-NRCS in their Field Office Technical Guide. Practice Standards will be based on specific local conditions. Practice standards will be those included in the NRCS FOTG; however, modification of those practice standards will be made as necessary.

The TSSWCB adopted the NRCS FOTG as the criteria applicable for water supply enhancement plans. This guide is specifically tailored for the geographic area of each SWCD.

The essential key practices utilized in all water supply enhancement plans are:

- Brush Management (314)
- Prescribed Grazing (528)
- Upland Wildlife Habitat Management (645)

The TSSWCB, in consultation with SWCDs, will approve a list of practices that are eligible for cost-share statewide (Section 8.3 Cost-Share Program). These practices may include chemical and mechanical methods and prescribed burning. Results of watershed studies may be used to evaluate control options and their feasibility.

Identifiable units must be established for each practice. An identifiable unit must be either all or an essential part or subdivision of a practice that when carried out is complete within itself and can be clearly identified. An identifiable unit also can be managed independently as to maintenance of the practice. Establishment of identifiable units and an average cost or a specified maximum cost permits cost-share payments to be made to producers when an identifiable unit is treated. A list of practices, applicable cost-share rates, average costs or specified maximum costs will be developed for each identifiable unit.

DEFERMENT

A 5% incentive is offered to landowners who defer grazing from treated areas for 90 days during the growing season following treatment to allow re-establishment of vegetation. Deferment can only begin once treatment is completed in a pasture. When deferment begins, the landowner must contact the SWCD. At least one status review will be conducted during the deferment. The 5% incentive is based on the actual amount paid for treatment in the deferred pasture.

REVEGETATION

Consistent with the practice standard for Brush Management (314) (NRCS 2013), mechanically treated brush control areas must be re-vegetated if 40% or more of the existing grass cover is destroyed by mechanical disturbance or if reseeding from existing seed sources will not provide adequate cover. In this case, the Range Planting practice standard (550) is supporting.

Further, rootplowing (a specific type of mechanical treatment) may cause significant structural changes of plant communities. As such, all rootplowed brush control areas must be seeded and/or planted to permanent vegetation. In this case, the Range Planting practice standard (550) is supporting.

COMPLETION SCHEDULE

Proper timing and sequence of land treatment are essential to successful implementation of any conservation program. This is true concerning either the entire project or individual landowner plans. One major factor that enters into a state cost-share program is the time limits placed on the use of state money. State funds are appropriated on a biennial basis. This will allow only two-year contracts at a maximum to implement brush control and request reimbursement even though the entire project may take several years to complete. Landowners are responsible for obtaining their own contractors to perform the brush control work.

Each cost-share agreement will include a maintenance agreement by which the landowner agrees to maintain the brush management practice for a period of ten years after implementing the plan.

Subsection 8.2.2 Wildlife Considerations

In Texas, the loss of native grassland habitats has been substantial; for example, Samson and Knopf (1994) report a 90% reduction of tallgrass prairie, a 30% reduction of mixed-grass prairie, and an 80% reduction of shortgrass prairie since European settlement. For many grassland-associated wildlife species, this habitat loss is compounded by brush encroachment (Arrington et al. 2002). This large-scale conversion from grasslands and savannahs to shrublands over the last 160 years has significantly impaired uplands and reduced percolation and surface flow of water from rainfall causing changes and loss in basic aquatic and terrestrial wildlife habitat (Arrington et al. 2002).

When compared with the TSSWCB Feasibility Studies, where brush control was assumed to occur on all land that had moderate or heavy brush, Arrington et al. (2002) suggests that both stream flow increases and water yield increases would not be significantly affected if brush control strategies that account for wildlife (e.g., slope and riparian restrictions) were imposed.

In order to meet objectives of restoring ecological function, properly designed brush management plans should account for the habitat requirements needed to maintain viable populations of brush- or woodland-associated wildlife species while improving habitat for grassland-associated wildlife species. However, as there is with any change in habitat, any brush management strategy implemented across the landscape will result in a shift in the wildlife community resulting in gains or losses for particular species, depending on changes in habitat. (Arrington et al. 2002)

The basic concern of the wildlife manager in implementing any brush management system has to do with the design and retention of a brush mosaic. Patterning of brush treatments is driven by wildlife considerations more than by any other set of management objectives. The design of a favorable habitat mosaic will be considered for each specific resource management plan.

The types of brush control patterns used will depend upon the terrain in the area to be treated. To a great degree, natural terrain features will dictate the types and conformation of patterns.

Sufficient brush cover should be left along watercourses, which usually serve as wildlife travel lanes. The width of the strips to be left for most wildlife can be determined by visual inspection. The strips of brush should be wide enough to prevent seeing through them at most points from December through February when most species have lost their leaves. All natural wildlife travel ways, which would include watercourses, saddles between ridges, headers or canyon beginnings, extensions of ridges, and any unusually high-quality wildlife food plants should be left.

When cleared strips extend for great distances, a belt or block of brush should be left every 200-300 yd to break up the open spaces and provide covered travel lanes for wildlife. In South Texas where the terrain is relatively flat with no prominent features, alternate strips of cleared areas and brush produce good results, although clearing in an irregular pattern is more desirable. In large areas the strips can be established in gently curving patterns to block excessive views, and belts or blocks of brush can be left at desirable intervals across cleared areas. Brush strips should be left along drainage areas or draws used as natural travel ways by wildlife.

Where cleared areas tend to be excessively large, islands of brush should be left interspersed within the cleared areas to provide escape cover. As with brush strips, the islands should be large enough that they cannot be seen through from December through February. Where islands do not provide sufficient escape cover, extensions or necks of brush can be left for escape cover and travel ways to prominent terrain features frequented by wildlife.

During the initial development of a resource management plan, extreme care should be taken to retain the many different types of woody food and cover plants necessary to maintain a resident wildlife population of all species. For example, woody plants or brush species are necessary to wild turkey populations, not only as food producing plants, but also as cover and roosting timber. Existing winter roost timber should be left standing. In association with this, brush and smaller trees under or adjacent to the roosting areas should be retained. Turkeys require cover as they enter and depart the roost and while loafing under the roost trees. Sufficient quantities of food-producing woody species such as chittum, hackberry, lotebush, oak, pecan, and elm also should be maintained.

Following mechanical treatment, some areas will require reseeding. The seeding mix should include forbs that benefit wildlife.

The improvement in range conditions through brush management will increase the available food supply for wildlife and domestic livestock. This additional food supply will improve the quality of the animals being produced. Brush should be managed in conjunction with sound range management practices.

Although some basic rules for brush management may be applied to all treated areas, the topography, types of vegetation, and wildlife species present on each ranch unit and even from pasture to pasture within a ranch will be different. Therefore, an on-the-ground inspection of the entire ranch is necessary prior to formulating sound management plans.

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

Subsection 8.2.3 Soil Erosion Potential

During the public review and comment period for the 2014 proposed *State Water Supply Enhancement Plan*, TSSWCB received several public comments that raised issues regarding the effects of brush control on soil erosion potential. Four observations are made below in response to the concerns raised.

First, the TSSWCB is the lead state agency responsible for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural nonpoint sources of water pollution (Agriculture Code §201.026). The agency's WSEP is designed to reinforce that mission. The required landowner conservation plans are designed to mitigate the impact of brush control on other natural resources.

Second, in all of the completed feasibility studies, the target brush to be controlled is replaced with native grass rangeland in the modeled simulations of brush control. As such, the projected water yields enhanced are not based on runoff from bare ground; treated areas are not assumed to be bare ground.

Third, the USDA-NRCS Practice Standard for brush management (NRCS 2013) recognizes that where erosion and sedimentation are resource concerns as a result of woody plant encroachment, brush management is undertaken for the purpose of restoring desired vegetative cover to control erosion and reduce sediment. Further, the NRCS Conservation Practice Physical Effects documentation indicates a slight-to-moderate decrease in sheet and rill soil erosion when brush management is performed.

Fourth, as previously discussed in Section 2.2, the USGS also collected suspended-sediment data during the study at the Honey Creek State Natural Area which evaluated the hydrologic effects of ashe juniper removal. Suspended-sediment loads were calculated from samples collected at the reference watershed and the treatment watershed. USGS found that during the post-treatment period, the relation between suspended-sediment loads and streamflow did exhibit a statistically significant difference. The data indicate that for the same streamflow, the suspended-sediment loads calculated from the treatment watershed were generally less than suspended-sediment loads calculated from the reference watershed during the post-treatment period. (Banta and Slattery 2011)

Section 8.3 Cost-Share Program

ELIGIBILITY FOR COST-SHARE PROGRAM

Cost-share assistance may only be allocated:

- To An Eligible Person,
- For Eligible Purposes,
- On Eligible Land,
- For Eligible Brush,
- For Eligible Practices.

Eligible Person – Any individual, partnership, administrator for a trust or estate, family-owned corporation, or other legal entity who as an owner, lessee, tenant, or sharecropper participates in an agricultural or wildlife operation within a WSEP Project Watershed, has adequate operational control (i.e., a written lease equal to the length of the WSEP contract or longer), and is a cooperator with the local SWCD shall be eligible for cost-share assistance.

Eligible Purposes – Cost-share assistance shall be available only for brush control included in an approved water supply enhancement plan and contract and determined to be needed by SWCDs to conserve water.

Eligible Land – Agricultural or wildlife land within a designated WSEP Project Watershed that is privately owned by an eligible person, leased by an eligible person over which the applicant has adequate control extending through the term of the WSEP contract period and written permission of the landowner, or owned by the State, a political subdivision of the State, or a nonprofit organization that holds land in trust for the State.

Ineligible Land – Cost-share funds shall not be used on land outside of a designated Project Watershed or on land not used for agricultural or wildlife production. Any land that is simultaneously receiving any cost-share money for brush control on the same acreage from a state, federal, or local government program (i.e., federal Farm Bill programs, TSSWCB Water Quality Management Plan Program, CWA §319(h) Nonpoint Source Grant) is not eligible, unless the TSSWCB finds that joint participation of the WSEP and any other programs will enhance the efficiency and effectiveness of a project and lessen the State's financial commitment to the project.

Eligible Brush – Moderate, heavy, and extra heavy mesquite, juniper, and mixed mesquite and juniper. In the O.H. Ivie watershed, moderate (i.e., normal) is defined as 9-19% canopy cover and heavy is defined as 20% or greater canopy cover. In all other watersheds, moderate is defined as 10-29% canopy cover, heavy is defined as 30-39% canopy cover, and extra heavy is defined as 40% or greater canopy cover. Canopy cover is determined for target species only (mesquite and juniper). Saltcedar, huisache, and Carrizo cane are assessed on a site-specific basis.

Eligible Practices – Those brush control measures (including deferment) included in an approved water supply enhancement plan, according to the USDA-NRCS FOTG.

COST-SHARE RATE

The TSSWCB will establish practices eligible for cost-share and their standards, specifications, maintenance, and expected life. The TSSWCB will establish the maximum cost-share rate for practices approved for the WSEP. Cost-share payments will be based on the most cost effective methods. The TSSWCB will establish average costs based on recommendations provided annually by the USDA-NRCS EQIP.

Subsection 8.3.1 General Criteria

Section 203.151 of the Agriculture Code created a cost-sharing program to be administered under Chapter 203 and rules adopted by the TSSWCB.

The TSSWCB adopted rules to administer the brush control cost-share program (31 TAC §§517.22-517.39) with the following program characteristics:

1. Not more than 70% of the total cost of a single brush control project may be made available as the State's share in cost-sharing.
2. Requests for allocations will be part of brush control project proposals submitted by SWCDs.
3. Approval of allocations. The TSSWCB shall consider, approve, reject, or adjust funding requests based on priority of projects and amount of available funding. Only SWCDs for which the TSSWCB has approved a Project Watershed are eligible for cost-share funds.

Subsection 8.3.2 Cost-Share Agreement

SWCDs may enter into cost-share agreements with individual landowners. Cost-share agreements must be based on an approved water supply enhancement plan developed by the landowners with assistance provided through the SWCD. Only those costs directly associated with removal of brush, as specified in the feasibility study for that watershed, are eligible for cost-share assistance.

A producer having a water supply enhancement plan may apply for cost-share by completing the appropriate TSSWCB forms.

SWCD COST-SHARE APPROVAL PROCESS

Only after approval of a water supply enhancement plan should the SWCD consider approval of a cost-share contract. SWCD approval of a water supply enhancement plan and cost-share assistance contract should be based on conformity with the USDA-NRCS FOTG, adherence to established priorities and policies, and the following considerations:

- Whether the water supply enhancement through brush control is to be carried out in a Project Watershed;
- the method of control that is to be used by the applicant;
- the plans for revegetation;
- the total cost of the water supply enhancement through brush control;
- the amount of land to be included;
- whether the applicant is financially able to provide his share of the money for the water supply enhancement through brush control;
- the cost-share percentage, if an applicant agrees to a higher degree of financial commitment;
- any comments and recommendations of the TPWD; and
- any other pertinent information considered necessary by the SWCD or the TSSWCB.

Subsection 8.3.3 Brush Control Methods

The TSSWCB is directed to approve all methods of brush control used under this program. The TSSWCB may approve methods of controlling brush based on a finding that the method:

1. has proven effective and efficient for controlling brush;
2. is cost efficient;
3. will have a beneficial impact on the development of water sources and wildlife habitat;
4. will maintain topsoil to prevent erosion or siltation of rivers or streams; and
5. will allow for revegetation of the area after the brush is removed with plants that are beneficial to stream flows, groundwater levels, and livestock and wildlife.

The TSSWCB will approve brush control methods for each project based upon information from the feasibility study along with other data or information the TSSWCB deems relevant. Approved methods will be transmitted to the appropriate SWCDs when funding allocations are approved.

It is the policy of the TSSWCB to provide cost-share on the basis of actual cost not to exceed the average cost. Where possible, cost-share assistance will be limited to the least costly methods. The least costly method must be technically acceptable with regard to wildlife considerations and effective in controlling problem species. No cost-share assistance will be provided for raking and piling except where this is required prior to root plowing.

Subsection 8.3.4 Maintenance of Brush Management and Follow-Up Treatment

Cost-share agreements must contain a commitment on the part of the landowner to maintain areas for which cost-share funding for brush control is received for a period of ten years after the initial brush control is accomplished.

Maintenance includes periodically re-treating the area with appropriate brush control methods to prevent brush reinfestation over the duration of the contract period. Maintenance treatments will be scheduled as needed according to specifications in the FOTG.

Statute, recently clarified by HB1808, emphasizes that follow-up brush control is entirely the landowner's financial responsibility and they cannot receive any additional state funds to do the follow-up brush control (Agriculture Code §203.162(c)).

FOLLOW-UP TREATMENT REQUIREMENTS

In accordance with the Agriculture Code, follow-up brush control treatment is required by the landowner on participating lands at no cost to the State.

Follow-up treatment scheduled in water supply enhancement landowner resource management plans:

<u>Mesquite, Mixed Brush, Saltcedar</u>: Follow-up treatment is scheduled three years after initial treatment if canopy (target species only) is above 5%.

<u>Juniper</u>: Follow-up treatment is scheduled eight years after initial treatment if canopy (target species only) is above 5%.

Subsection 8.3.5 Certification of Practice Implementation

Upon completion of brush control activities on any identifiable unit of land, the SWCD must certify to the TSSWCB that the practice has been implemented in accordance with specifications on that portion of the planned area.

Performance certifications are conducted when practices to be cost-shared are implemented. The SWCD must then certify that the practice meets the standards set forth in the FOTG. Canopy cover of target species must be reduced to less than 5% to be certified.

Subsection 8.3.6 Cost-Share Payments

Based upon certification by the SWCD that brush control has been implemented according to specifications on all or any identifiable unit of land in a water supply enhancement plan, the TSSWCB may process a request for payment of cost-share funds and cause payment to be made directly to the landowner.

It is the policy of the TSSWCB to provide cost-share on the basis of actual cost not to exceed the average cost established in the project's implementation plan. Landowners are responsible for 100% of the costs that exceed the average costs established in the project's implementation plan.

The SWCD shall determine eligibility of the applicant to receive payment of cost-share assistance and provide certification to the TSSWCB that measures have been installed consistent with established standards.

Payments are based on the number of acres treated times the cost-share rate times the actual cost not to exceed the average cost set by the project's implementation plan.

The project's implementation plan may establish maximum cost-share limits less than the amount set by the TSSWCB.

Partial payment can be made for completed practices that are listed separately on the application for cost-share.

Subsection 8.3.7 Status Reviews

The method for assessing brush density and brush type shall be the same as used when developing the landowner's water supply enhancement plan. The method for canopy cover assessments will be used for

1) initial brush assessment to develop each landowner plan,
2) performance certification of brush control conducted for cost-share, and
3) status review of maintenance and follow-up treatment.

STATUS REVIEW SCHEDULE

All water supply enhancement landowner resource management plans and cost-share contracts will include requirements for status reviews to be conducted in accordance with an established schedule.

Status reviews will be conducted within three to five years after initial treatment of brush to determine if the canopy (target species only) is above 5%.

A second status review will be performed eight to nine years after initial treatment.

If the producer is found out of compliance, they will not be eligible for another WSEP contract for a period of ten years.

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Chapter 9 Statewide WSEP Water Yield Estimate

Water yield projections originate from computer models in published brush control feasibility studies.

Table 9.1. Water Yielded from Brush Control Under the WSEP (or BCP) through FY2013

Watershed	State Cost per Treated Ac	Treated Ac	Gal/Ac per Yr	Gal/Yr Based on Treated Ac	Total Water Yield for Life of Project[1]
Lk Arrowhead / Wichita Rvr	$ 20.92	49,932	162,035	8,090,683,010	80,906,830,095
Lk Brownwood	$ 146.34	4,016	95,696	384,315,136	3,843,151,360
Canadian Rvr / Lk Meredith[3]	$ 92.49	16,850	817,651	13,777,419,350	55,109,677,400
Carrizo-Wilcox Aquifer	$ 226.54	234			
Edwards Aquifer Recharge Zone	$ 155.75	3,515	217,790	765,531,850	7,655,318,500
Frio Rvr					
Hondo Crk					
Medina Rvr					
Upper Nueces Rvr					
Sabinal Rvr					
Seco Crk					
Ft Phantom Hill Rsrvr	$ 164.50	1,632	103,460	168,846,720	1,688,467,200
Frio Rvr / Choke Canyon Rsrvr	$ 24.22	14,274	73,056	1,042,801,344	10,428,013,440
Upper Guadalupe Rvr / Canyon Lk	$ 123.71	6,007	217,790	1,308,264,530	13,082,645,300
O.H. Ivie Rsrvr					
Lk Ballinger[2]	$ 45.00	7,800	55,354	431,761,200	4,317,612,000
Oak Creek Lk[2]	$ 47.00	16,224	47,225	766,178,400	7,661,784,000
Lk Kemp					
North Concho Rvr[2]	$ 45.50	327,000	26,068	8,524,236,000	85,242,360,000
O.C. Fisher Lk	$ 104.98	10,066	26,068	262,408,308	2,624,083,084
Nueces Rvr / Lk Corpus Christi	$ 27.65	18,433	73,056	1,346,641,248	13,466,412,480
Palo Pinto Rsrvr	$ 139.48	1,063	195,455	207,768,665	2,077,686,650
Pedernales Rvr / Lk Travis	$ 72.00	73,578	217,790	16,024,552,620	160,245,526,200
E.V. Spence Rsrvr					
Lk Champion[2]	$ 43.00	14,994	31,535	472,835,790	4,728,357,900
Lk J.B. Thomas					
Twin Buttes Rsrvr	$ 68.03	235,474	25,028	5,893,443,272	58,934,432,720
Lk Nasworthy					
Steele Crk[4]	$ 162.50	1,894	26,068	49,372,792	493,727,920
Lower Guadalupe Rvr[4]	$ 111.69	1,000			
Pecos Rvr / Upper Colorado Rvr[2, 3, 4]	$ 70.78	10,580	1,450,037	15,341,391,460	61,365,565,840
Greenbelt Rsrvr[2, 3, 4]	$ 87.50	571	977,553	558,182,763	2,232,731,052
Hubbard Creek Rsrvr[2, 3, 4]	$ 58.75	506	977,553	494,641,818	1,978,567,272
Mountain Creek Lk[2, 4]	$ 49.00	1,440	46,389	66,800,160	668,001,600
TOTAL		817,083		75,978,076,436 = 233,168 ac-ft	578,750,952,013 = 1,776,121 ac-ft

1 The total water yield is based on the watershed projects having a lifespan of 4 or 10 years depending on the type of brush treated.
2 Watershed Project Completed
3 Life of Project = 4 year lifespan
4 gal/ac per yr is not based on WSEP feasibility study

Full implementation of brush control, as modeled in all published Feasibility Studies for the 22 approved Project Watersheds, has a total projected annual water yield of 2.273M ac-ft of water that could be enhanced if the State was able to provide cost-share to landowners to treat 15.75M ac of brush in those watersheds (Table 9.2). This depends greatly upon the extent of voluntary landowner participation and on the climatic conditions across the state that influence the sequence of drought and rainfall events.

Table 9.2. Projected Water Yield from Feasibility Studies based on Full Implementation

Watershed	# of Sub-basins	Total Watershed Area (ac)	Brush Treatment Area (ac)	Total Annual Water Yield (ac-ft)	Total Cost for Implementation[1]
Lk Arrowhead / Wichita Rvr	28	529,354	277,657	151,622	$ 23,197,951
Lk Brownwood	48	997,039	462,141	180,782	$ 66,038,484
Canadian Rvr	312	4,712,828	3,949,974	102,820	$ 107,523,056
Carrizo-Wilcox Aquifer[2]	44	687,097	687,097	117,031	
Edwards Aquifer - Frio Rvr	23	244,850	81,141	20,810	$ 11,583,961
Edwards Aquifer - Hondo Crk	5	57,551	20,006	9,322	$ 3,005,230
Edwards Aquifer - Medina Rvr	25	301,832	99,105	51,198	$ 14,721,982
Edwards Aquifer - Upper Nueces Rvr	18	1,075,052	776,730	112,892	$ 118,648,447
Edwards Aquifer - Sabinal Rvr	11	135,605	51,324	17,423	$ 7,892,994
Edwards Aquifer - Seco Crk	13	32,406	14,627	6,040	$ 2,299,591
Ft Phantom Hill Rsrvr	17	301,118	138,396	44,351	$ 13,171,594
Frio Rvr / Choke Canyon Rsrvr	26	1,329094	882,882	226,756	$ 90,289,449
Upper Guadalupe Rvr[2]	23	918,791	197,905	20,705	
O.H. Ivie Rsrvr	46	1,935,142	733,402	102,658	$ 60,179,154
Lk Kemp	48	1,311,305	833,413	152,004	$ 59,939,843
North Concho Rvr	18	953,402	365,691	22,344	$ 15,918,726
Nueces Rvr / Lk Corpus Christi	95	4,283,443	3,188,796	688,248	$ 345,742,986
Palo Pinto Rsrvr	22	296,400	139,425	76,268	$ 18,526,912
Pedernales Rvr / Lk Travis	35	800,276	203,754	3,423	$ 23,614,409
E.V. Spence Rsrvr	26	3,130,263	1,324,333	79,789	$ 93,295,415
Lk J.B. Thomas	7	1,103,799	301,765	8,743	$ 17,418,311
Twin Buttes Rsrvr	82	2,423,854	1,015,407	77,990	$ 76,313,708
TOTAL	972	27,560,501	15,744,971	2,273,219	$ 1,169,322,203

1 Total "capital" cost (i.e., State's cost-share) for full implementation of brush treatment acres identified in Feasibility Studies. For comparability, costs from Feasibility Studies adjusted for inflation to 2014 dollars.

2 No economic analysis was performed with this Feasibility Study.

Section 9.1 Monitoring Effectiveness of WSEP

Fish and Rainwater (2007) described an approach for implementing a monitoring program to assess the effectiveness of the WSEP.

The major concern of the program is enhancement of streamflow. In order to measure such flows, it is necessary to install continuous streamflow recorders at the outlets of the treated subwatersheds. It would be best to have both pre- and post-treatment data to demonstrate the ranges of flow values. The typical flow recording system would most likely be a water level sensor, such as a pressure transducer, installed at a fixed channel cross-section, such as a paved low-water crossing, broad-crested weir, or a fixed measuring flume. The system would have a relationship between water surface elevation in the stream and flow rate, and allow continuous data collection so that baseflow and runoff components could always be observed. Pressure transducers typically come with electronic data loggers that can be downloaded.

Continuous observation of rainfall is just as important as streamflow, so that the source of the runoff can be estimated. Multiple recording rain gauges, such as the tipping bucket type that can sense rainfall to the nearest 0.01 in, should be placed at strategic locations across the watershed to allow estimation of the areal and temporal distribution of rainfall for each storm event. These rain gauges can store data in data loggers for occasional downloading.

Observation of local groundwater conditions should be done through monitoring wells in the shallow alluvial aquifer in and near the streambed. The elevations of the groundwater table in the monitoring wells can be compared to each other and to the elevation of the water surface in the stream to demonstrate which way the groundwater is flowing and the changes in groundwater storage over time. The groundwater levels can be continuously monitored with pressure transducers, or manually measured less often if readily accessible.

Estimation of ET losses through vegetation within the target areas of the treated subwatershed can be done by using site visits, aerial photography, and satellite imagery to identify the effectiveness of brush management over the treated areas of the subwatershed. Potential ET can be estimated with local weather stations that measure and record wind speed, relative humidity, net solar radiation, and temperature. Actual ET can then be estimated as proportional to the potential ET based on plant type and seasonal variations in water consumption.

The best situation for application of hydrologic monitoring to confirm positive impacts of brush control would be to have several years of pre-treatment data to compare to several years of post-treatment data. Unfortunately, this situation is unlikely for the subwatersheds that have already been or will soon be treated. It is possible that two similar subwatersheds can be selected, instrumented, and observed with one receiving brush treatment and the other left untreated. The hydrologic behaviors of the two subwatersheds over several years could then be later compared to determine the impact of treatment.

An over-riding concern about hydrologic monitoring for streamflow enhancement, or any other purpose, is that the longer the observation period is the more confident one is in the findings. Installation of equipment to measure streamflow often seems to cause a drought. All those concerned with streamflow enhancement, whether through brush control or other watershed management techniques, are encouraged to be patient and allow multiple years of data collection and analyses to observe a reasonable range of weather conditions over time.

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Appendix A Summary of Public Comments Received and the State's Responses

The public comment period extended from June 6, 2014 through July 21, 2014. A public hearing was held on July 1, 2014 in Temple. Notice regarding the comment period and hearing were published in the *Texas Register* and an agency news release was published. Sixty-three (63) sets of comments were received in response to the published draft of the *State Water Supply Enhancement Plan* and the proposed amendments to 31 TAC Chapter 517, Subchapter B, Cost-Share Assistance for Water Supply Enhancement (§§517.22-517.37).

PREAMBLE – In 2011, the 82nd Texas Legislature passed HB1808 which established the new WSEP administered by TSSWCB. As directed by the Legislature and codified in statute, the TSSWCB must prepare and adopt a *State Water Supply Enhancement Plan*. The TSSWCB respects and appreciates the wide difference of constructive opinions reflected in the comments regarding brush control and water supply enhancement. The *State Plan* is a "living" document that must be frequently revised. TSSWCB is committed to examining every issue and concern in depth and will work with those interested in making this *Plan* and Program the best it can be for the citizens of Texas.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
01-01	06-24-2014	Dr. Matthew Berg, Texas A&M University		X	In general, information on the selection of participating hydrologists, the performance of feasibility studies and prioritization efforts, and the operation of the Scientific Advisory Committee are very much in doubt as written and should be amended.	No changes to the document were made in response to this comment.
01-02	06-24-2014	Dr. Matthew Berg, Texas A&M University	X		While §517.25(c) explains that the TSSWCB will consult with stakeholders, including hydrologists and representatives from SWCDs, to develop standard methods of reporting the projected water yield, there is no description of the process for identifying these individuals. Moreover, this duty would be more appropriately delegated to the Scientific Advisory Committee mentioned occasionally in the Plan.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
01-03	06-24-2014	Dr. Matthew Berg, Texas A&M University		X	Further, the Plan appears to suggest this standard method has already been determined as average annual gallons per treated acre of brush throughout the simulation period. Either this standard method will be determined by hydrologists and stakeholders through a defined process, or it has already been decided with no identified input. As written, this is not clear.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
01-04	06-24-2014	Dr. Matthew Berg, Texas A&M University	X		In §517.26(a), assistance in identifying a hydrologist with appropriate expertise is wise. However, there is no explanation of the requirements for this person or group of persons. A rigorous set of minimum requirements should be provided to ensure adequate implementation of feasibility studies. Top priority should be given to hydrologists with previous experience with water budgets in the proposed project area itself.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
01-05	06-24-2014	Dr. Matthew Berg, Texas A&M University	X		Similarly, §517.26(d) neither explains the composition of the Scientific Advisory Committee nor lays out criteria for selection to this committee, a significant oversight, particularly if this group is to address scientific questions. Further, this group is not previously mentioned in the Plan. More information should be presented to identify this committee, its responsibilities, and its coordination. This group should include representatives of multiple academic institutions and multiple government agencies, at the very least.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
01-06	06-24-2014	Dr. Matthew Berg, Texas A&M University	X		Further, while the Scientific Advisory Committee "will consider science-oriented questions", §517.25(e)(1) explains that the TSSWCB "may consider scientific research…" This earlier mention should be changed to a more definitive incorporation of science in the prioritization process and throughout implementation of the Plan.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
01-07	06-24-2014	Dr. Matthew Berg, Texas A&M University	X		In requiring prior geospatial analysis, §517.38(b) does not provide any information on how landscape characteristics will be internally ranked and/or weighted. This lays a foundation for subjective and inadequate feasibility study results, particularly as identified by unclear language in (e). Furthermore, in (d), the four brush control priority zones are ambiguous, and it remains to be seen how these will be used to prioritize and implement a proposed project. More detail should be included to make this approach defensible.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
01-08	06-24-2014	Dr. Matthew Berg, Texas A&M University	X		Again, given that projects may address enhancement of either infiltration or runoff (§517.38(e)), significant familiarity with the project area on the part of the participating hydrologists is a must, as these components of the water budget vary tremendously across Texas shrublands potentially eligible for control efforts.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
02-01	06-26-2014	Con Mims, Executive Director, Nueces River Authority		X	For many years, Nueces River Authority has championed a recognized education program centered on promoting good land stewardship and preservation of riparian function as ways to enhance surface and ground water quantity and quality. During this time, we have appreciated a close working relationship with TSSWCB.	No changes to the document were made in response to this comment.
02-02	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X	X	Our primary interests regarding the draft rules and amendments pertain to (1) having Arundo donax included as a noxious plant and made eligible for brush control funding, due to its aggressive reproduction, high water consumption, and threats to riparian function,	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
02-03	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X	X	(2) insuring that the rules exclude projects that could cause runoff from the land that results in erosion and/or siltation of waterways, especially since one of the stated goals in these rules is to control brush to enhance runoff,	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
02-04	06-26-2014	Con Mims, Executive Director, Nueces River Authority		X	(3) insuring that brush control is not implemented in ways that could adversely affect the function of riparian zones,	No changes to the document were made in response to this comment.
02-05	06-26-2014	Con Mims, Executive Director, Nueces River Authority		X	(4) expanding the role of the Science Advisory Committee in evaluation of projects to ensure consistent and scientifically broad based analysis and defining its membership. Accordingly, we offer the following changes for your consideration:	No changes to the document were made in response to this comment.
02-06	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Section 517.22 (6) be changed to include Arundo donax (Giant Cane) as a noxious plant that consumes water to a degree that is detrimental to water conservation and adverse to the purpose of Chapter 517 and that is eligible for brush control funding under this Chapter.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
02-07	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Section 517.25 (d) be changed to include, as an item for the TSSWCB to consider in prioritizing projects, the recommendations of the Science Advisory Committee referred to in 517.26 (d).	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
02-08	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Section 517.25 (e) be changed to read, in prioritizing projects, the TSSWCB shall, instead of may, consider scientific research and other relevant criteria.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
02-09	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Section 517.26 be changed to require a feasibility study for every proposed project.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
02-10	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Section 517.26 (d) be changed to describe the composition of the Science Advisory Committee such that it includes not less than three (3) individuals, with one having recognized expertise in the field of range management, one having recognized expertise in the field of hydrology, and one having recognized expertise in the field of environmental science.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
02-11	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Section 517.31 (a) be changed to require consultation with the Science Advisory Committee in the TSSWCB's study and approval of methods to control brush and the overall impacts of projects.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
02-12	06-26-2014	Con Mims, Executive Director, Nueces River Authority	X		Add 517.31 (6) noting that the TSSWCB may approve a method for use under the cost- sharing program if it finds that the proposed method preserves or enhances riparian function.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
03-01	06-26-2014	Gary Valentine		X	The solution to the stated purpose of this document is to slow our state's population growth. Regardless of what we do to increase water supply, I fear that it will not be sufficient if projected population growth comes true. Fewer people and conserving water use by all segments of our population is the solution to our water supply dilemma.	No changes to the document were made in response to this comment.
03-02	06-26-2014	Gary Valentine		X	I was perusing the organizations represented on the Science Advisory Committee, Stakeholder Committee and other contributors. I noticed no representatives from TPWD, USDA-NRCS, NGOs such as Sierra Club and Environmental Defense Fund, and universities other than TTU and Tarleton State. I think some of these organizations should have been involved in document preparation, not merely commenting on the draft. I've found that comments made during the comment period can be rather easily rationalized away.	No changes to the document were made in response to this comment. TPWD will be added to the Science Advisory Committee.
03-03	06-26-2014	Gary Valentine		X	On page 12, you have a list of Acronyms. Actually, for the most of your list is Abbreviations. Acronyms are words made from abbreviations, and you have a few in your list. Not included in the list is TSCRA (Texas and Southwest Cattle Raisers), SARA (San Antonio River Authority and acronym) and HDR (???).	The document was revised in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
04-01	06-26-2014	Dr. Bradford P. Wilcox, Texas A&M University; Dr. James Heilman, Texas A&M University; Dr. Georgianne Moore, Texas A&M University; Dr. Thomas Boutton, Texas A&M University; Dr. Susan Schwinning, Texas State University; Dr. Kevin McInnes, Texas A&M University; Dr. Binayak Mohanty, Texas A&M University; Dr. Sam Fuhlendorf, Oklahoma State University; Dr. John Walker, Texas A&M University; Dr. Steve Archer, University of Arizona; Dr. Matthew Berg, Texas A&M University; Dr. Keith Owens, Oklahoma State University		X	There are a number of points in the Plan (2014) with which we agree. (1) We agree that Texas faces very serious water supply challenges in the future, particularly during the inevitable drought periods. (2) We agree that extensive portions of the State that once were grasslands and savannas are now woodlands. (3) We agree that managing brush or woody plants potentially provides many benefits—including increased forage production, richer biodiversity, improved wildlife habitat, and rejuvenation of small springs. For these reasons, brush management is an indispensible practice on Texas rangelands.	No changes to the document were made in response to this comment.
04-02	06-26-2014	Wilcox et al.		X	However, we fundamentally disagree with the Plan's underlying tenet that brush management is a viable strategy for increasing water supplied from Texas rangelands. The weight of scientific evidence, as highlighted in several recent reviews (e.g. National Academy of Sciences 2008), is quite clear that there is little support for this assumption.	No changes to the document were made in response to this comment. See Preamble.
04-03	06-26-2014	Wilcox et al.		X	Evidence presented in the Plan in support of the assumption that brush management will enhance water supplies is equivocal and does not acknowledge much of the research conducted over the past decade. Further, the Plan relies heavily on reports that have not been published or vetted in peer-reviewed journals. We contend that based on the current understanding of rangeland hydrology (Huxman et al. 2005, Shafroth et al. 2010, Archer et al. 2011, Moore and Heilman 2011) that a more appropriate tenet would be that brush management will NOT increase water yields.	No changes to the document were made in response to this comment. See Preamble.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
04-04	06-26-2014	Wilcox et al.		X	With respect to Texas, considerable research has been done in the last ten years by a number of scientific teams. None of these studies has provided the slightest evidence that brush management is a viable strategy for increasing water supplies. Because most of these studies were not mentioned in the Plan, we briefly summarize below the key findings of recent research in three major rangeland areas: the Rolling Plains, the Edwards Plateau, and South Texas. In addition, we summarize findings of recent work related to invasive shrubs in riparian zones. More detailed reviews can be found in various scientific reports, the most recent and comprehensive being Archer et al. (2011).	No changes to the document were made in response to this comment.
04-05	06-26-2014	Wilcox et al.		X	For the Rolling Plains region, there is solid evidence that brush control will not increase water supply. The scientific evidence for this conclusion is very strong and consistent across many studies (Carlson et al. 1990, Dugas and Mayeux 1991, Wilcox 2002, Wilcox et al. 2006a). Ironically, the strongest evidence comes from the North Concho Project, cited in the Plan as a success story. The North Concho Project has been one of the more comprehensive and coordinated brush control efforts in Texas. Between 2000 and 2005, about 1200 km2 of the 3100 km2 watershed was cleared of both mesquite and juniper in the hope of increasing flows. As highlighted by Saleh et al. (2009), water planners were projecting that flows in the North Concho would increase three to fivefold as a result of this $14M program.	No changes to the document were made in response to this comment.
04-06	06-26-2014	Wilcox et al.		X	However, not only has there been no perceptible increase in flow in the North Concho to date, there may even have been declines since the brush control program was implemented. This important finding, well-documented in the scientific literature (Wilcox et al. 2008, Wilcox et al. 2010), was not noted in the Plan. In spite of the obvious failure of this project, TSSWCB continues to inappropriately market the North Concho Project as a success story.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
04-07	06-26-2014	Wilcox et al.		X	The situation in the Edwards Plateau is more complicated. Indeed, there is good evidence that at small scales shrub clearing has led to decreases in interception and ET and increases in flow from small springs and seeps (Huang et al. 2006, Owens et al. 2006, Wilcox et al. 2006b, Heilman et al. 2009). However, other studies examining both streamflow and cave recharge following brush clearing have found no changes (Wilcox et al. 2005, Gregory et al. 2009, Bazan et al. 2013). More significantly, a recent study (also ignored in the Plan) clearly documents that at broad scales, streamflow has increased at the same time that brush cover has increased—calling into question the viability of removing shrubs to further increase streamflow (Wilcox and Huang 2010).	No changes to the document were made in response to this comment.
04-08	06-26-2014	Wilcox et al.		X	The reasons for these apparently contradictory findings are complex but appear related to the fact that infiltration rates in shrubland soils are higher than those in overgrazed grassland soils. In other words, in spite of popular perceptions to the contrary, increases in woody plants have not caused streamflow in the Edwards Plateau to decline but in fact have contributed to higher streamflows. In summary, at this time there is no evidence that water supply in the Edwards Plateau region can be increased via shrub control.	No changes to the document were made in response to this comment.
04-09	06-26-2014	Wilcox et al.		X	The one area of Texas rangeland where measurable water-yield gains may be achieved through brush management are the shrublands and woodlands overlying the Carrizo Wilcox Aquifer in South Texas. In this area, because of the deep and sandy soils, both water and tree roots may penetrate to great depths. As shown in one study, the removal of trees and shrubs may result in increased groundwater recharge during wet years, but these increases are modest and short-lived (Moore et al. 2012). Thus, brush management as economically viable strategy for increasing water yield in this region, while meriting additional research, appears unlikely.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
04-10	06-26-2014	Wilcox et al.		X	The Plan further suggests that clearing of invasive riparian vegetation (saltcedar and Russian olive) also offers the opportunity for water salvage. This notion is consistent with the results of some earlier work (including our own) (Wilcox et al. 2006b). However, recent comprehensive and high-level scientific reviews provide compelling evidence that there is little opportunity for increasing water supplies through removal of these shrubs (Shafroth et al. 2010, Doody et al. 2011). These conclusions have been largely verified in Texas where saltcedar was eradicated along 60 river miles of the Pecos River between 1999 and 2001. Yet, to date there is no scientific evidence of any measureable influence on streamflow in the Pecos (McDonald et al. 2013).	No changes to the document were made in response to this comment.
04-11	06-26-2014	Wilcox et al.		X	Because it has yet to be demonstrated that large-scale brush management can increase water yields, the Plan is asking that modeling analysis be used to justify brush management. We have nothing against models and use them in our own work; but we caution that modeling results can be, and have been in the past, quite misleading if not just plain wrong in their projections. The best (or worst) example of this is the SWAT model that projected a fivefold increase in the streamflow of the North Concho River following brush clearing (Saleh et al. 2009). Modeling results are but one perspective and should not supersede other evidence that brush management will not result in increases in water supply. Further – models can be easily manipulated to produce the desired results.	No changes to the document were made in response to this comment.
04-12	06-26-2014	Wilcox et al.		X	The scientific evidence is overwhelming that shrub control will NOT increase water supply in Texas. Scientists at Texas A&M University and AgriLife Research have been at the forefront of this research and have published their results in highly respected scientific journals. None of these results have been challenged or disputed and have been largely accepted in the general scientific community.	No changes to the document were made in response to this comment. See Preamble.
04-13	06-26-2014	Wilcox et al.		X	Further, two large-scale shrub clearing projects have already been carried out in Texas (North Concho River, Pecos River), both funded by federal and state sources, on the premise that they would increase water supply. But in both cases, these projects have been a bust in terms of any measurable increases in water.	No changes to the document were made in response to this comment.
04-14	06-26-2014	Wilcox et al.		X	For these reasons, we argue that the feasibility studies called for in the Plan would not be an effective strategy for dealing with the real and serious water challenges in Texas.	No changes to the document were made in response to this comment. See Preamble.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
04-15	06-26-2014	Wilcox et al.		X	As such, we believe the Plan as currently designed is a poor use of taxpayer money and we recommend that it not go forward.	No changes to the document were made in response to this comment. See Preamble.
04-16	06-26-2014	Wilcox et al.		X	Again, we reiterate: brush management is an indispensible practice on Texas rangelands and it may be appropriate for local, state, and federal governments to provide assistance—both technical and financial. However, it strikes us as disingenuous and misleading to make an argument to Texas taxpayers that there is reason to expect that brush management will improve water supply in Texas. This simply is not the case.	No changes to the document were made in response to this comment. See Preamble.
05-01	06-27-2014	Courtney Brittain		X	I am writing to express my great concern with the proposed revision of the Texas State WSEP. Based on numerous scientific studies and our state's own experience it is clear that wide-spread brush control does not improve water supplies. We have spent millions in subsidizing brush removal to increase our water supply and it hasn't done any of what we hoped and expected.	No changes to the document were made in response to this comment.
05-02	06-27-2014	Courtney Brittain		X	To continue to spend money on this now proven false theory is not only unwise but a slap in the face to the taxpayers footing the bill. I understand the other benefits of brush removal and the state's desire to subsidize it for legitimate reasons. But please do not insult me and my fellow taxpayers by claiming it will benefit our water supply. I urge you to look for real answers to our water supply problems, not throw good money after bad with the proposed plan.	No changes to the document were made in response to this comment. See Preamble.
06-01	06-27-2014	Bill Eikenhorst, DVM		X	As written and presented to my current level of understanding, this plan appears to be grossly misguided and biased on its character and content. I am not a range scientist or hydrologist, however I do know how to use these expert resources and I trust their judgment based on the obvious and repeatable findings over numerous studies across varying locations and time frames across Texas. I recognize that it seems intuitive that removing brush/woody species from specific landscapes in an aggressive manner would yield greater returns of water.	No changes to the document were made in response to this comment.
06-02	06-27-2014	Bill Eikenhorst, DVM		X	I also understand there are small scale and testimonial examples of enhanced spring flows/water production after brush removal; however, it is very clear to anyone who can and cares to read the body of research that this tactic is NOT in any way a strategy that should be casually incentivized at the expense of the Taxpayer.	No changes to the document were made in response to this comment. See Preamble.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
06-03	06-27-2014	Bill Eikenhorst, DVM		X	I am and will remain an advocate for brush management as an effective and active tool for landowners to have in their tool box and apply based on their specific goals and objectives for their properties. I am not and will remain opposed to the indiscriminate and wholesale financing of brush control as a water producing strategy. It simply isn't an honest solution.	No changes to the document were made in response to this comment. See Preamble.
06-04	06-27-2014	Bill Eikenhorst, DVM		X	I am and will remain an advocate of voluntary land stewardship excellence, in a balanced and comprehensive application, as one tactic to promote water quality and quantity.	No changes to the document were made in response to this comment.
06-05	06-27-2014	Bill Eikenhorst, DVM		X	As a Washington County landowner I have had personal and a long history of family connection to our local SWCD. The men and women that support soil and water conservation locally and statewide have always had my support and admiration. I find it hard to believe that the currently recommended plan has emerged from within that body of caring land stewards? Texas can do better than this!	No changes to the document were made in response to this comment.
06-06	06-27-2014	Bill Eikenhorst, DVM		X	For reference, I support and fully trust the assessments and comments provided by Steve Nelle as well as a host of other credible experts on the subject.	No changes to the document were made in response to this comment.
07-01	06-27-2014	Steve Nelle		X	The partnerships between local SWCDs and natural resource professionals have been productive and beneficial. I have respect for most of the local SWCD Directors whom I have worked with over the last 38 years. These men and women volunteer their time and experience, often for several decades, to help support local soil and water conservation programs and priorities. In most cases, these individuals are salt-of-the-earth people, with a deep and genuine love for the land. Most of them have a multigenerational interest in land and water stewardship and truly want what is best for natural resource management in their local SWCD. These local SWCDs and their directors are the backbone of grassroots soil and water conservation efforts in Texas. I want to applaud these men and women for their commitment to conservation and their willing public service and I do not target any of my remarks below toward them.	No changes to the document were made in response to this comment.
07-02	06-27-2014	Steve Nelle		X	I have serious reservations about the Plan as proposed by the TSSWCB. My role as a responsible citizen and conservative taxpayer also affects my position about WSEP.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
07-03	06-27-2014	Steve Nelle		X	Noxious and Invasive Brush. The justification of government-funded brush control programs is based on the perceived need to reduce or control noxious or invasive species that can create serious economic or ecological problems.	No changes to the document were made in response to this comment.
07-04	06-27-2014	Steve Nelle		X	The terms “noxious and invading brush” have been misused so much over that past 50 years, that most people have no idea that these words have definite legal status. It may be surprising to discover that juniper and mesquite are not listed as noxious or invasive species by the state of Texas. The TDA maintains the official list of Noxious and Invasive Plants http://info.sos.state.tx.us/fids/200701978-1.html. Only one of the three targeted WSEP brush species (saltcedar) is on the official list.	No changes to the document were made in response to this comment.
07-05	06-27-2014	Steve Nelle		X	The TDA defines noxious and invasive plants as “any plant species that has a serious potential to cause economic, or ecologic harm to the agriculture, horticultural, native plants, ecology and waterways of Texas.” Mesquite and juniper fail to meet these criteria. Therefore, there may not even be a legal jurisdictional justification for juniper and mesquite control under WSEP.	No changes to the document were made in response to this comment.
07-06	06-27-2014	Steve Nelle		X	The TISCC http://www.tiscc.texas.gov/ nor the Texas Invasive Plant and Pest Council http://www.texasinvasives.org/pages/about.php includes juniper or mesquite in their list of noxious or invasive species. These groups are comprised of many partner organizations and agencies devoted to invasive species issues, including TPWD, TSSWCB, AgriLife Extension, TWDB, Ladybird Johnson Wildflower Center, conservation organizations, academia, green industry and others. Three different governmental, professional, conservation entities do not include juniper or mesquite in their official definition or designation of invasive or noxious species, creating a very dubious rationale for TSSWCB to target these species for control.	No changes to the document were made in response to this comment.
07-07	06-27-2014	Steve Nelle		X	It Does Not Work. Even though juniper and mesquite are not even designated as invasive or noxious plants, the main reason to reject the WSEP is that the approach being promoted simply does not work on a large scale. For many decades, going back before the 1960s, government agencies, landowners and the general public have advocated the control of brush for the purpose of increasing the public water supply. Unfortunately this has not worked.	No changes to the document were made in response to this comment. See Preamble.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
07-08	06-27-2014	Steve Nelle		X	Despite a massive amount of public opinion, wishful thinking, myth and misperception, there is no compelling evidence that brush control increases the water supply. Many well-intentioned people have tried to make the case for water enhancement through brush control but the evidence is clearly lacking. There are plenty of anecdotal accounts of small springs and seeps coming to life in some locations but no credible data to indicate that the water supply for Texas can be substantially improved by doing brush control. Although there are plenty of strong feelings about it, there simply is no convincing evidence.	No changes to the document were made in response to this comment. See Preamble.
07-09	06-27-2014	Steve Nelle		X	It all began with the popular but shortsighted and ill-fated North Concho Brush Program in 2000. Policy makers and legislators were warned and advised by a few prominent and courageous scientists and range management professionals of the anticipated failure of the program. Despite the warnings and the lack of success, the program was quickly expanded to many other locations. Now, after 14 years and more than $62M of brush control payments, Texas taxpayers want to know "where is the water?" There is no extra water. My plea to policy makers is to please re-evaluate your support for the continuation of this doomed approach, which is guaranteed to fail again and again.	No changes to the document were made in response to this comment. See Preamble.
07-10	06-27-2014	Steve Nelle		X	No Simple Solutions. H.L. Menken stated a profound truth that applies very well to the brush control / water issue. He said, "For every complex problem, there is a solution that is simple, neat, and wrong". Rangeland brush / water dynamics certainly qualify as a complex issue, and an issue for which there are no simple or easy solutions. The simplistic attempts used in the past have not worked and there is no reason to believe that a continuation of these unsuccessful attempts will work in the future. Albert Einstein said that a definition of insanity is "doing the same thing over and over again and expecting different results." No government agency wants to be guilty of this kind of insanity and taxpayers do not appreciate this kind of wasteful and ineffective spending.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
07-11	06-27-2014	Steve Nelle		X	Popularity Should Not Drive Programs. Brush control has been a popular and useful practice for decades and it is especially popular when the government subsidizes it. There are many legitimate and beneficial reasons why landowners conduct brush control. It is a vital practice for most ranchers who wish to increase livestock production and improve wildlife habitat. Landowners naturally are glad to have the government subsidize much of their brush control costs. Landowners in general, even the most honest, conservative and upright landowners are not likely to advocate for the elimination of a program that has paid them large sums of money to do brush control. However, just because a program is popular does not mean that it is a good or effective investment of public funds.	No changes to the document were made in response to this comment.
07-12	06-27-2014	Steve Nelle		X	The profession of range management has long advocated brush control for its many beneficial uses. Up until recently, many range management professionals have actively promoted the water benefits of brush control. It was a strongly held traditional belief, indoctrinated into the profession, that brush was responsible for the drying of creeks, rivers and aquifers, and that brush control could restore streamflow and aquifer recharge. However, true professionals do not let traditional beliefs and paradigms trump new information and improved science.	No changes to the document were made in response to this comment.
07-13	06-27-2014	Steve Nelle		X	The great and famous range scientist, Dr. E. J. Dyksterhuis made this bold and relevant statement many years ago, "The professional rangeman must often make an independent and even unpopular stand. The non-professional is content with the promotion of that which is currently acceptable or popular."	No changes to the document were made in response to this comment.
07-14	06-27-2014	Steve Nelle		X	Use Good Science. The science of range management and rangeland hydrology is undergoing a turnaround and major paradigm shift regarding brush control. Because of new and better science, many enlightened scientists and professionals are now gaining a better understanding of the rangeland water cycle and the complex relationships between brush and water. The profession is beginning to reject the simple and ineffective solutions of the past. The profession is trying to understand the big picture of watershed management.	No changes to the document were made in response to this comment.

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07-15	06-27-2014	Steve Nelle		X	It is highly unethical to ignore and reject the best scientific information available simply because it does not support your position. The most credible rangeland hydrology science in Texas is being conducted by Dr. Bradford Wilcox of Texas A&M. His professional and scientific credentials are recognized worldwide; yet his extensive research findings have been mostly ignored by TSSWCB and other natural resource agencies. It is shameful and disgraceful that the most highly qualified and renowned scientist / expert has largely been disregarded by TSSWCB policy makers in developing the WSEP and its predecessor, the Texas BCP.	No changes to the document were made in response to this comment. See Preamble.
07-16	06-27-2014	Steve Nelle		X	False, Flawed, Misleading and Unethical. The Texas WSEP is a totally flawed plan because the premise on which it is based is false. The plan cannot be fixed by comment, revision or compromise.	No changes to the document were made in response to this comment. See Preamble.
07-17	06-27-2014	Steve Nelle		X	Cherry picking the studies and data that support your position while ignoring the science that contradicts your position is a tactic of bad government and bad policy. It perpetuates distrust and disgust among taxpayers and citizens who expect honesty, integrity and results from government programs.	No changes to the document were made in response to this comment.
07-18	06-27-2014	Steve Nelle		X	One of the signs of integrity is the willingness to reverse a position that is proven faulty. Please reconsider your position before you move ahead with such a scientifically impotent plan. It is sad and discouraging that a major state agency would carelessly and thoughtlessly continue in such an unsuccessful direction. Government agencies and government programs should be guided by the highest ethics, not by popularity or to gain additional political power.	No changes to the document were made in response to this comment. See Preamble.
07-19	06-27-2014	Steve Nelle		X	Policy Based on Myth. Although well intentioned, the concept of increasing Texas water supplies by conducting brush control is rooted in myth. It continues to get attention because the myth has gained so much popular press for many decades.	No changes to the document were made in response to this comment.
07-20	06-27-2014	Steve Nelle		X	The bottom line is that the enhancement of water supplies with brush control is based on information that has been refuted multiple times and in multiple ways. It sounds good and seems logical on the surface, but it has not worked out. It was a grand experiment that failed and has wasted public resources that can be put to better use.	No changes to the document were made in response to this comment. See Preamble.

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07-21	06-27-2014	Steve Nelle		X	A New and Unfortunate Approach to "Water Enhancement" - Land Degradation. Always in the past, when brush control was advocated for water enhancement, the goal and intent was to increase infiltration of rainfall into the soil so that it would hopefully recharge aquifers and enhance base flow of streams and springs. Even though this approach has not proven successful on a large scale, the intent was noble - to improve the plant cover and enhance the natural workings of the water cycle.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
07-22	06-27-2014	Steve Nelle		X	Sadly, one of the new twists of the WSEP is not at all noble - the intentional increase in runoff. Runoff increases when land is degraded. When runoff is increased, the land loses water and slowly dries out. The premise of good land and water stewardship has always been to improve the plant cover in order to catch, retain and hold water in the soil, for a prolonged natural release of the water. Conversely, as the cover of vegetation is reduced, more water runs off and the runoff is faster.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
07-23	06-27-2014	Steve Nelle		X	The saddest part of this runoff-enhancing approach is that it will work - but only with a great series of negative side effects. History, science and experience have shown that runoff can indeed be increased by the removal and reduction of vegetation. The intentional or unintentional degradation of watersheds will produce greater runoff rates, but the side effects are extreme, long lasting and damaging to Texas land, water and people. The side effects of increasing rainfall runoff include: Increased erosion; Loss of essential land productivity; Loss of land value; Loss of wildlife habitat value; Increase in flooding; Reduction of base flow; Damage to riparian areas; Reduced water quality; Damage to aquatic habitat; and Sedimentation of downstream waterbodies.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
07-24	06-27-2014	Steve Nelle		X	There is always a predictable ripple effect to bad land and water policy. Legislators, politicians and agencies who promote such bad policy will need to be held accountable for the damage and degradation they cause.	No changes to the document were made in response to this comment.

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07-25	06-27-2014	Steve Nelle		X	Final Comments. Sadly, the TSSWCB and Austin politicians who have supported these plans are continuing down the road of ineffective and even damaging land and water policy. The WSEP is based on false and misleading information and a poor scientific understanding of the water cycle and watershed management. No credible or responsible scientist or conservationist will want their name associated with this plan. The plan represents the worst in public policy and bureaucracy.	No changes to the document were made in response to this comment. See Preamble.
08-01	06-27-2014	Gary Valentine		X	On pages 96 and 97 the draft discusses “Wildlife Considerations.” There are lots of “should be’s” and “can be’s” when discussing wildlife and brush removal. “Should be’s” and “can be’s” are not requirements; “Will be’s” are. If public funds are used to pay for brush removal to enhance water supplies, wildlife habitat measures should be required, not only considered.	No changes to the document were made in response to this comment.
09-01	06-29-2014	Ruthie Russell		X	I have listened for many years to reasons for brush control. What about land properties that now have good native grass cover and increased diversity due to brush control, Less transevaporation, more infiltration, less erosion or sediment loss and soil loss -Thus cleaner water in our streams?	No changes to the document were made in response to this comment.
09-02	06-29-2014	Ruthie Russell		X	Wildlife greatly enhanced. More weeds and wildflowers, thus more insects, quail coveys, edge habitat for deer and other animals. When you look deep inside our cedar thickets there is very little grass and plant diversity. Obviously brushy corridors need to be left but meadows creating edge have been desirable to wildlife on our ranch.	No changes to the document were made in response to this comment.
09-03	06-29-2014	Ruthie Russell		X	When floods do occur runoff is cleaner and erosion less. We feel the quality of our river water and riparian habitat has been greatly enhanced, which adds to water quality downstream. Don't forget the water quality that is improved by brush control.	No changes to the document were made in response to this comment.
10-01	07-01-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	The Hill Country Alliance, our network of thousands of interested Hill Country residents and stakeholders, as well as the Texas Wildlife Association at the request of TWA President Greg Simons and CEO David Yeates, register our formal request to extend the comment period for the recently released Plan. Because of these concerns, we join the request by the Nueces River Authority, the Texas Wildlife Association, and others to extend the public comment period on the WSEP by 90 days. This will allow time to evaluate if adequate safeguards are in the plan and how those safeguards might be improved.	No changes to the document were made in response to this comment.

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10-02	07-01-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	HCA convenes expert and interest teams on a variety of issues. One of these teams, our Land Ethics team, includes widely respected land management experts including David K. Langford, Steve Nelle, Jill Nokes, Brad Wilcox, Bill Neiman, Jim Stanley, and Sky Lewey. Individually many of these team members or their organizations have already submitted thoughtful written comments. I am here to draw your attention to the depth and breadth of those comments and also to point out that collectively this group is united in their agreement that encouraging practices that have a goal of increasing runoff is counterproductive and dangerous to the long-term health of our water systems, particularly in the Texas Hill Country region.	No changes to the document were made in response to this comment.
10-03	07-01-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	In the plan 97,374 Hill Country acres are targeted for treatment. The implementation of WSEP can significantly alter the natural Hill Country landscape, advance erosion, and promote stream degradation.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
10-04	07-01-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	We would like the chance to work with you to ensure that our statewide land management policies are designed to protect the long- term health of our natural resources.	No changes to the document were made in response to this comment.
11-01	07-01-2014	Jim Stanley		X	There is an old saying that goes something like this: "For every complex problem there is a solution that is simple, easy to describe and understand-and wrong". The TSSWCB plan would seem to fit this description perfectly. The idea that getting rainfall to run off the land as quickly as possible flies in the face of everything we know about land management. The idea that cedar (or mesquite) is bad and getting rid of it will solve our problems is misguided.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
11-02	07-01-2014	Jim Stanley		X	The most famous story in Texas about removing cedar and getting more water is probably the Bamberger Ranch Preserve where J. David Bamberger removed a lot of cedar from a property with no springs or permanent water and got returned spring flow that eventually became a permanent creek which eventually flows into the Pedernales and the folks in Austin get water they wouldn't have had and they didn't have to pay a dime. But the rest of the story is critical. Bamberger didn't just remove cedar, he planted huge amounts of native grass seed, planted native hardwoods and forbs, and used every method possible to SLOW DOWN the flow of rainwater over the land. In other words, he was practicing good land stewardship before the term was commonly used.	No changes to the document were made in response to this comment.

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11-03	07-01-2014	Jim Stanley		X	No two places are identical, and others attempting to duplicate Bamberger's actions may not achieve the same success. But the point that seems to be missing from the TSSWCB's plan is the idea that how the land is managed matters. It matters in terms of the fate of rainwater, in terms of the health and function of riparian areas, in terms of wildlife habitat, in terms of carrying capacity for both livestock and wildlife, in terms of the resilience of the land, and in terms of the value of the land.	No changes to the document were made in response to this comment.
11-04	07-01-2014	Jim Stanley		X	By focusing solely on the removal of brush with the goal of getting water to run off the land as quickly and completely as possible, TSSWCB is setting up the conditions that will result in degraded properties. Without any attention to how the land is managed after brush removal, some landowners will do nothing to mitigate erosion, some will overgraze the land giving rise to more erosion, some will continue to overgraze the riparian areas further reducing its function, and some will introduce non-native invasive grasses that further degrade the wildlife habitat. Furthermore, with less infiltration into the ground, the local water tables and riparian sponge areas will dry up and permanent creeks will become only wet-weather creeks. A healthy functioning ecosystem is simply more complicated than the TSSWCB plan takes into account.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency’s WSEP is designed to reinforce that mission.
11-05	07-01-2014	Jim Stanley		X	The long-term consequences of these practices will be loss of productivity and property values and, eventually, desertification of the landscape. All the result of government policies. Aldo Leopold said, “The urge to comprehend must precede to urge to reform.” This doesn't seem to be the case with this plan.	No changes to the document were made in response to this comment.
12-01	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Thank you for the opportunity to comment on the draft Plan developed by the TSSWCB. Improved vegetation management practices on rangelands are a potentially valuable means of improving water availability in Texas. While the proposed areas covered by this plan do not directly impact the City of Austin at this time, we recognize that this document may also be used to guide brush management activities elsewhere in the state, including in the sensitive karst regions immediately to the west of Austin. We offer for your consideration comments on some elements of the plan that may limit its effectiveness in terms of increasing water supply or that may lead to unintended environmental degradation.	No changes to the document were made in response to this comment.

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12-02	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Regarding the effectiveness of the plan, we wish to direct your attention to several recent studies that indicate that brush removal may not be the most effective approach for increasing water supply through vegetation management in Central Texas. Specifically:	No changes to the document were made in response to this comment.
12-03	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	The plan does not account for accumulating evidence that woody plant encroachment has less impact on water supply than other poor management practices, such as overgrazing, that lead to loss of vegetative cover (Wilcox BP, Huang Y. 2010. Woody plant encroachment paradox: rivers rebound as degraded grasslands convert to woodlands. Geophysical Research Letters 37: 07402).	No changes to the document were made in response to this comment.
12-04	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	The plan does not account for evidence that Juniperus ashei displays greater water use efficiency than previously assumed (Bendevis, Owens, Heilman, McInnes 2009).	No changes to the document were made in response to this comment.
12-05	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	The plan does not account for evidence that J. ashei does not appear to directly utilize groundwater sources (Heilman, McInnes, Kjelgaard, Owens, Schwinning 2009).	No changes to the document were made in response to this comment.
12-06	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Additionally, there are changes to the Plan proposal and implementation process that would allow a greater degree of environmental protection than currently provided: The plan states that "Areas that are designated as project habitat or endangered species habitat" will be excluded from brush control activities. It is not clear, however, how the presence or absence of endangered species habitat will be evaluated for proposed sites. Proposed WSEs should include an evaluation of potential endangered species impacts by a qualified biologist.	No changes to the document were made in response to this comment.
12-07	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	The plan states that brush control methods should "maintain topsoil to prevent erosion or siltation of rivers or streams". The methods should also account for possible impacts of heavy equipment on substrate, such as in areas with near-surface or exposed fractured limestone. These considerations should be incorporated into WSEs as appropriate. Plans should allow for use of skid-steer, rubber-wheeled vehicles for brush clearing to minimize impacts to soil and substrate.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
12-08	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Grazing deferment or reduced grazing density should be required for 90 days post-removal to allow establishment of herbaceous vegetation.	No changes to the document were made in response to this comment.

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12-09	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Status Review of cost-shared WSEs should incorporate an assessment within two weeks of the termination of brush clearing activities to determine whether required revegetation or other stabilization measures are being implemented. Additional follow-up should be performed at six months to evaluation vegetative condition. A percentage of cost-share could be withheld until this time and distributed based on compliance with revegetation requirements.	No changes to the document were made in response to this comment.
12-10	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Brush clearing activities should receive less emphasis than other rangeland improvement efforts focused on water supply enhancement in Central Texas.	No changes to the document were made in response to this comment. See Preamble.
12-11	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	Brush clearing plans should more clearly account for soil compaction, the structure of underlying substrate and the possible presence of endangered species.	No changes to the document were made in response to this comment.
12-12	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	These plans should include additional measures to ensure successful revegetation of sites following brush clearing activities.	No changes to the document were made in response to this comment.
12-13	07-02-2014	Chris Herrington, Watershed Protection Department, City of Austin		X	The Plan is a potentially valuable conservation and land management document and we appreciate the effort that has been put into it.	No changes to the document were made in response to this comment.
13-01	07-02-2014	Con Mims, Executive Director, Nueces River Authority	X	X	As noted in our June 23, 2014 comments on TSSWCB's proposed Rule amendments, Nueces River Authority is concerned about the potential adverse impacts that improper implementation of the Plan could have on the surface and groundwater resources of the Nueces Basin. Underlying our concerns are the possible interactions of many factors.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
13-02	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The large amount of acreage within the Nueces Basin that is covered by feasibility studies that have, currently, been accepted by TSSWCB as established WSEP Project Watersheds.	No changes to the document were made in response to this comment.
13-03	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The conclusion that most, or all, of the woody vegetation must be killed.	No changes to the document were made in response to this comment.
13-04	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The driving goal of enhancing rainwater runoff.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
13-05	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The potential for erosion and stream siltation with improper implementation of projects.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.

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13-06	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The reliance on models to select projects for implementation. The testimony that results are frequently not consistent with expectations. The large number of physical variables that can affect outcomes.	No changes to the document were made in response to this comment.
13-07	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The potential influence of public water suppliers and water marketers in the project award process.	No changes to the document were made in response to this comment.
13-08	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	The possible large scale redirection of water historically percolating into groundwater formations to surface water destinations and the long term effects on spring flows.	No changes to the document were made in response to this comment.
13-09	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	We recognize that TSSWCB is trying to comply with legislative direction. But, this new water supply enhancement through brush control campaign could have serious long term consequences in the Nueces Basin, if not carefully implemented and monitored.	No changes to the document were made in response to this comment.
13-10	07-02-2014	Con Mims, Executive Director, Nueces River Authority		X	Because of these concerns, we would appreciate your extending the public comment period by ninety (90) days to allow time to evaluate if adequate safeguards are in the Plan and how those safeguards can be improved.	No changes to the document were made in response to this comment.
14-01	07-02-2014	Dr. Cody Scott, Vice President, Texas Section Society for Range Management		X	Brush control, as it relates to potential water yields, continues to be advocated on rangelands throughout Texas. Unfortunately, brush control on most rangelands in Texas has not shown any significant increase in water availability for public use.	No changes to the document were made in response to this comment. See Preamble.
14-02	07-02-2014	Dr. Cody Scott, Vice President, Texas Section Society for Range Management		X	In addition, the majority for research completed since 2000 suggests that selective brush control will not enhance water availability on most range sites. This is apparently because not all soils, ecological sites, plant communities, and geologic formations will respond to woody vegetation removal and manipulation in the same manner.	No changes to the document were made in response to this comment.
14-03	07-02-2014	Dr. Cody Scott, Vice President, Texas Section Society for Range Management		X	The removal of woody plant cover from rangelands should be in pursuit of rangeland restoration as it relates to the function of the hydrologic cycle, restoration of the historic or desired plant community, and the benefits derived from such treatment. These include potential increased water yields, increased water quality, and increased plant and animal diversity. These potential benefits will only occur if climate patterns permit and management levels of the rangeland are increased and applied following treatment.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
14-04	07-02-2014	Dr. Cody Scott, Vice President, Texas Section Society for Range Management		X	Grazing management and follow-up treatment of brush species are paramount for the success of this mission. Implementation of brush management is generally thought of as the first practice implemented in the restoration process for rangelands. This practice alone cannot yield desired results if proper grazing management is not carried out following brush management.	No changes to the document were made in response to this comment.
14-05	07-02-2014	Dr. Cody Scott, Vice President, Texas Section Society for Range Management		X	The Texas Section Society for Range Management advocates that proper grazing management in combination with brush management efforts can benefit the hydrologic function and ecological sustainability of Texas rangelands. The Plan must support a resource management plan that encompasses total resource management on individual ranching units as well as an entire watershed approach to be an effective program. It is the implementation and management of this resource management plan that will keep the rangeland resources of Texas sustainable for future generations.	No changes to the document were made in response to this comment.
14-06	07-02-2014	Dr. Cody Scott, Vice President, Texas Section Society for Range Management		X	Sound management decisions should be based on the best available knowledge. For this reason, TSSRM recommends that the state of Texas continue to support research focused on understanding the desired economic and environmental outcomes for brush control, restoration of hydrologic function, and rangeland management.	No changes to the document were made in response to this comment.
15-01	07-03-2014	Dr. Ernest B. Fish, Texas Tech University		X	My purpose in writing is to provide input with respect to the new proposed guidelines for the Plan dated May 2014. In my opinion, these guidelines provide a significant improvement with respect to the process for selection of locations for implementing vegetation management to increase water yields.	No changes to the document were made in response to this comment.
15-02	07-03-2014	Dr. Ernest B. Fish, Texas Tech University		X	The guidelines provide a mechanism for considering a variety of physical characteristics with potential to impact hydrologic responses of a watershed. By giving consideration to each of these characteristics, it will be possible to prioritize the selection of areas and willing landowners for effective implementation of water yield enhancement management activities.	No changes to the document were made in response to this comment.
15-03	07-03-2014	Dr. Ernest B. Fish, Texas Tech University		X	The guidelines also require participant landowners to implement follow-up programs insuring that enrolled areas are appropriately managed after treatment.	No changes to the document were made in response to this comment.

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16-01	07-03-2014	David K. Langford		X	First, carefully planned and monitored brush control has many benefits, including increased forage production and habitat diversity. Moreover, as my family can attest, brush management, done properly, in appropriate locations, and maintained over time, can revive springs, seeps, and creeks under certain circumstances in limited acreage. However, greatly increasing the water supply on a large scale via brush control has never shown any degree of success. This statement is supported by a lifetime as a Hill Country landowner, and more than 40 years' experience with conservation policy and current research. I am grateful to range and wildlife scientists such as Steve Nelle, Jim Stanley, and Brad Wilcox and his illustrious team who have brought their expertise to bear on this issue.	No changes to the document were made in response to this comment.
16-02	07-03-2014	David K. Langford		X	Second, I recognize that TSSWCB is attempting to comply with legislative direction, but the current plan to implement a wide scale brush control program designed to increase runoff on more than 90,000 ac in the upper Nueces River Basin is short-sighted, not visionary, and contrary to the common-sense conservation of soil and water resources. The upper Nueces River Basin is home to some of the Hill Country's most rugged and most erosion-prone land. Ill-planned and/or poorly implemented brush control will lead to degradation of the landscape and the water as the ashe juniper, mesquite, and other roots that are holding the thin topsoil in place are removed. Soil that was once anchored is now free to rush down the hillside and into the streams that feed the Nueces, as well as the river itself.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
16-03	07-03-2014	David K. Langford		X	In order for TSSWCB to comply with the Legislature's direction, all proposed brush control campaigns must be carefully implemented and monitored because it could have serious long-term consequences for both surface and groundwater in the upper, and likely the entire, Nueces Basin. (All these comments apply to the WSEP's unwise intentions for over 70,000 ac in the Pedernales Basin as well.) The consequences could result from the possible interactions of many factors.	No changes to the document were made in response to this comment.
16-04	07-03-2014	David K. Langford		X	The large amount of acreage within the Nueces Basin that is covered by feasibility studies that have currently been accepted by TSSWCB as established WSEP Project Watersheds.	No changes to the document were made in response to this comment.
16-05	07-03-2014	David K. Langford		X	The conclusion that most, or all, of the woody vegetation must be killed.	No changes to the document were made in response to this comment.

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16-06	07-03-2014	David K. Langford		X	The driving goal of enhancing rainwater runoff.	No changes to the document were made in response to this comment.
16-07	07-03-2014	David K. Langford		X	The potential for erosion and stream siltation with improper implementation of projects.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
16-08	07-03-2014	David K. Langford		X	The reliance on models to select projects for implementation. The testimony that results are frequently not consistent with expectations. The large number of physical variables that can affect outcomes.	No changes to the document were made in response to this comment.
16-09	07-03-2014	David K. Langford		X	The potential influence of public water suppliers and water marketers in the project award process.	No changes to the document were made in response to this comment.
16-10	07-03-2014	David K. Langford		X	The possible large scale reduction of water historically percolating into groundwater formations to surface water destinations and the long term effects on spring flows.	No changes to the document were made in response to this comment.
16-11	07-03-2014	David K. Langford		X	Because of these concerns, also identified and expressed by the Nueces River Authority, I would respectfully request the TSSWCB extend the public comment period by ninety (90) days to allow time evaluate if adequate safeguards are in the Plan and how those safeguards can be improved.	No changes to the document were made in response to this comment.
17-01	07-03-2014	Suzanne B. Scott, General Manager, San Antonio River Authority	X	X	The SARA supports the adoption of the draft Plan and associated proposed rule amendments. The State of Texas empowered the SARA to preserve, protect and manage the resources and environment of the San Antonio River and its tributaries. Our district spans Bexar, Goliad, Karnes and Wilson counties, yet our concern for the quality and quantity of water extends our focus beyond these boundaries, as factors outside the district contribute to the health and well-being of the river and our communities. As a regional entity SARA advocates for a regional approach to addressing water quality and quantity issues.	No changes to the document were made in response to this comment.
17-02	07-03-2014	Suzanne B. Scott, General Manager, San Antonio River Authority		X	The draft Plan recognizes SARA projects such as the EDYS studies in Wilson, Karnes, Goliad, Refugio and Victoria counties as ongoing water supply enhancement feasibility studies. The draft plan also notes the SARA and USGS study determining the effects of huisache removal on ET in South Central Texas as a study that is critical to the WSEP. SARA is pleased these studies are acknowledged as supporting the Plan.	No changes to the document were made in response to this comment.

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17-03	07-03-2014	Suzanne B. Scott, General Manager, San Antonio River Authority		X	One other initiative SARA has implemented in our fiscal year 2014/15 budget provides for $100,000 in cost-share support for the implementation of prioritized conservation practices within the Goliad, Karnes, Wilson, and Alamo SWCDs. SARA supports the adoption of the draft Plan as well as conservation practices aimed at protecting and improving water quality and quantity throughout our jurisdiction.	No changes to the document were made in response to this comment.
18-01	07-04-2014	Van Baize		X	I support the state program. Water will become even more of an important issue in the future. The current crisis in Texas will get worse as additional people relocate here. Brush control is one key to solving the problem.	No changes to the document were made in response to this comment.
19-01	07-05-2014	Michael McCulloch, DVM		X	I agree with Mr. Langford's comments below. Though I do not have direct knowledge of the Laurels Ranch, I have witnessed the conditions Mr. Langford described elsewhere.	No changes to the document were made in response to this comment.
19-02	07-05-2014	Michael McCulloch, DVM		X	One comment I would make is that there is brush control and then there is Saltcedar (Tamarisk) control. I am still an advocate for Saltcedar control, but it is a different "creature" than what is being described here.	No changes to the document were made in response to this comment.
20-01	07-07-2014	J. David Bamberger		X	For forty-five years I have been a very active conservationist on 5500 ac of a previously badly managed land in the hill country near Johnson City. Forty-five years ago this ranch was literally covered with cedar. There was very little grass cover and no water. With some guidance from the Soil Conservation Service, we developed a twenty year plan of habitat restoration. More than anything else it was a plan to selectively remove cedar and to prepare the area cleared for native grass planting.	No changes to the document were made in response to this comment.
20-02	07-07-2014	J. David Bamberger		X	I was warned early on that these hills have very shallow calcareous soils and that traditional heavy hill country rains on this newly exposed surface would wash away what little soil was there. To minimize this, we did not clear cut the cedar, but left over 600 ac of it. We then scarified the exposed surface with a spring tooth cultivator to prepare a seed bed for the planting of native grass seed. We did receive some two, three and four inch rains, but the scarified soil and having selectively left some cedar kept runoff to a bare minimum.	No changes to the document were made in response to this comment.

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20-03	07-07-2014	J. David Bamberger		X	Two and one half years later, with grasses growing – including on the steep hillsides – an old spring, dormant for years, came back to life. Not big by Texas standards, but it was cased off and produced one gal per minute. This produced 1440 gal in a 24 hour day. Enough for any family. As we continued the restoration, we developed many seeps into springs in the same manner. The water gravity flows into storage tanks that collectively hold 45,000 gal.	No changes to the document were made in response to this comment.
20-04	07-07-2014	J. David Bamberger		X	From the very beginning, 45 years ago, our goal was the direct opposite of the WSEP Plan. We wanted to slow down the run off of rainfall so as to recharge what is known by geologists as our "perched" or "local" aquifer. This aquifer gets recharged with every rainfall all because it's covered with grass. – Grass is the single biggest contributor to groundwater. A few of our springs ceased to flow after a few years into the current drought, but for the most part our aquifer, like a giant sponge, continues to produce water because of grass. We have learned a great deal about removing cedar and recharging groundwater during this forty-five years.	No changes to the document were made in response to this comment.
20-05	07-07-2014	J. David Bamberger		X	Our story on this issue is not a myth nor is it anecdotal. It's an accepted fact supported by research done by federal and state conservation agencies, photographs, diaries, television, newspaper and magazine articles and so on. My experience is shared by countless other landowners. However, the degree of success anyone will have will depend on the geology and topography of the land being cleared.	No changes to the document were made in response to this comment.
20-06	07-07-2014	J. David Bamberger		X	It is my opinion that the WSEP as now planned would be a disaster. Causing erosion, loss of habitat for wildlife and domestic livestock as well as the loss of precious soil. This would be more so particularly in the Nueces River watershed. Increasing runoff by any method is a mistake and one that will take generations to rectify.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
21-01	07-07-2014	Greg Simons, President, Texas Wildlife Association		X	In recent weeks, there have been concerns expressed by various TWA leaders, and others, regarding certain aspects of the proposed revisions of TSWSEP. Most specifically, there appears to be growing concerns regarding the proposed revisions which relate to wide-spread brush clearing as a means of increasing the state's water supply.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
21-02	07-07-2014	Greg Simons, President, Texas Wildlife Association		X	Brush control, as a range management practice, has certainly proven to be an important tool in the landowner's toolbox when properly applied, and TWA supports the idea of landowners being provided with the resources and allowances that they need to integrate sound stewardship practices into their work.	No changes to the document were made in response to this comment.
21-03	07-07-2014	Greg Simons, President, Texas Wildlife Association		X	Research continues to prove that the millions of dollars that were spent along the North Concho River watershed have had no measurable benefits in adding to streamflow or aquifer recharge that has translated into more water being added into our local reservoirs. Further, many of the properties that participated in the subsidized large-scale brush clearing activities in the North Concho Basin actually diminished the wildlife and land values on some of those properties due to excessive clearing practices. In retrospect, many natural resource specialists, as well as local citizens, feel as though those subsidies could have been leveraged in a more meaningful way, providing greater public-service impacts with those public-service funds, but as they say, hindsight is a great teacher.	No changes to the document were made in response to this comment.
21-04	07-07-2014	Greg Simons, President, Texas Wildlife Association		X	Such application strategies that proved costly and largely ineffective with the North Concho project may have even less desirable results if applied to the Nueces River Basin. Land features associated with the Nueces have some characteristics that are more fragile regarding soil stability, and intensive wide-spread brush clearing along many areas of the upper Nueces has the potential to result in serious soil erosion. Such erosion could result in diminished land productivity, while also creating siltation impacts along the Nueces watercourse, resulting in decreased water quality, decreased aquatic productivity, and potentially having negative impacts as far downstream as where the Nueces empties into the bay areas along the coast.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
21-05	07-07-2014	Greg Simons, President, Texas Wildlife Association		X	Education, outreach, advocacy, and funding for Texas water supplies are more important now than ever before, and with one of the fastest growing populations of any state, combined with prolonged drought, it becomes even more important that fund leveraging and outreach hit as close to the bull's-eye as possible. We must minimize mistakes as we continue to look for ways to refine conservation practices relating to water abundance and water quality, and using the carpenter's rule of "measuring twice and cutting once" could never be more apropos than it is today with water for Texas and water for Texans.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
21-06	07-07-2014	Greg Simons, President, Texas Wildlife Association		X	I recognize that TSSWCB recently extended the comment period by 14 days, and that allowance is greatly appreciated. However, considering the scope, scale, and nature of what is at stake here, TWA would like to respectfully request that a 90 day extension be granted on the comment period. TWA would like to be a positive part of this process and it is important that stakeholder communities and special interest groups be granted additional and adequate time to become a valuable voice for the TSWSEP.	No changes to the document were made in response to this comment.
22-01	07-08-2014	Wilson Scaling, Director, Little Wichita SWCD #560		X	I support the WSEP. As we know this is a long term method to increase not only quantity, but also quality of water in the lakes that supply our drinking water.	No changes to the document were made in response to this comment.
22-02	07-08-2014	Wilson Scaling, Director, Little Wichita SWCD #560		X	Also it helps control soil erosion due to the increase in grass production on the native pastureland throughout the state.	No changes to the document were made in response to this comment.
22-03	07-08-2014	Wilson Scaling, Director, Little Wichita SWCD #560		X	Mesquite is the worst “water thief” known! And it can only be controlled as it is impossible to kill. I have personally seen this on many tours throughout Texas during the time. I was Chief of the USDA Soil Conservation Service from 1985 through 1990. I also have spent a lifetime in ranching in Clay County Texas and can show you what mesquite control has done on my ranch in this long term drought.	No changes to the document were made in response to this comment.
23-01	07-09-2014	Dr. Ken Rainwater, Texas Tech University		X	I have had the privilege of working with the team of the WSEP since 2007 as they improved the program’s scientific foundation and administrative procedures to meet required statutory intentions. The program has come a long way since its work began in earnest in the late 1990s.	No changes to the document were made in response to this comment.
23-02	07-09-2014	Dr. Ken Rainwater, Texas Tech University		X	Since 2007, the WSEP has embraced the appropriate hydrologic principles that control the potential for increased water yield to surface and groundwater as invasive woody species are removed from watersheds, modern geographic information system (GIS) applications to accurately characterize the target watersheds, and a straightforward ranking procedure to compare proposed cost-share projects.	No changes to the document were made in response to this comment.
23-03	07-09-2014	Dr. Ken Rainwater, Texas Tech University		X	The Plan currently under consideration for TSSWCB approval provides good descriptions of the current activities of the WSEP, and I recommend it be approved and applied by the TSSWCB.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
23-04	07-09-2014	Dr. Ken Rainwater, Texas Tech University		X	The WSEP and TSSWCB responded to the recent review by the Texas Sunset Commission by updating and applying the language of the statute that defines their scope of work. When applied properly, the procedures clearly meet the intent of the statute and provide defensible decisions for the management of these funds from Texas taxpayers. The WSEP also sets examples for land stewardship that can be emulated by other government programs or by private landowner investments.	No changes to the document were made in response to this comment.
23-05	07-09-2014	Dr. Ken Rainwater, Texas Tech University		X	Added potential benefits can occur where brush removal reduces wildfire risks.	The document was revised in response to this comment.
23-06	07-09-2014	Dr. Ken Rainwater, Texas Tech University		X	As with most water supply concerns, adequate rainfall is necessary to see full benefits of our manipulation of watershed hydrologic responses. We have to be ready when the rains come, and we cannot let temporary drought conditions prevent appropriate management techniques that can eventually benefit urban and rural Texans.	No changes to the document were made in response to this comment.
24-01	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority		X	The Upper Guadalupe River Authority (UGRA) has, in the past, enthusiastically supported the TSSWCB's WSEP and its precursor the Texas BCP. These programs have provided critical resources to landowners in Kerr County, Texas, to facilitate water enhancement through brush and range management activities.	No changes to the document were made in response to this comment.
24-02	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority		X	Previously, we worked with TSSWCB staff and Kerr County SWCD Directors on project proposals and funding, and contributed funds to the development of the SWAT watershed model of the upper Guadalupe River watershed.	No changes to the document were made in response to this comment.
24-03	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority		X	UGRA's Water Enhancement Program further assists Kerr County landowners with brush management activities by providing an additional incentive on completed projects of 25% of the amount paid by TSSWCB. Since the inception of the program in January 2010, a total of 73 applications in Kerr County have been funded for $249,950 resulting in water enhancement through brush management on 7,217 ac.	No changes to the document were made in response to this comment.
24-04	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority	X	X	UGRA will continue to support water enhancement through brush management in Kerr County, but we are concerned that the evaluation criteria outlined in the draft Plan will not rank Kerr County a priority for future WSEP funding. The draft plan outlines criteria that will favor large population centers at the expense of small, yet essential, population centers like Kerrville.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.

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24-05	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority		X	The SWAT watershed model of the upper Guadalupe River simulates the effects of brush management on water yields to Canyon Lake, and does not consider increased yields to Nimitz Lake, a source of Kerrville's water supply. The water supply enhanced in Kerr County through brush management not only benefits Kerr County's water users, but benefits all water users downstream to Canyon Lake.	No changes to the document were made in response to this comment.
24-06	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority		X	New endeavors sometimes have unintended consequences. We do not believe the intent of the upper Guadalupe River SWAT model was to exclude water supply enhancement in rural and small metropolitan areas. Unfortunately, the primary use of the model has been to calculate potential yield to Canyon Lake totally ignoring potential yield to Kerrville's water supply, Nimitz Lake.	No changes to the document were made in response to this comment.
24-07	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority		X	We respectfully ask that the model also be used to evaluate potential yields to Nimitz Lake from brush management activities in the contributing sub-basins. This improvement will maximize potential yields to both municipal supply lakes in the upper Guadalupe River Basin, Nimitz and Canyon.	No changes to the document were made in response to this comment.
24-08	07-10-2014	Raymond L. Buck, Jr., General Manager, Upper Guadalupe River Authority	X	X	We urge the TSSWCB to enhance the evaluation criteria with this additional parameter in order to be equitable to all water users and not simply for the largest population centers.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
25-01	07-11-2014	Jack Clarke, Chairman, Kerr County SWCD #217		X	YES to the Plan.	No changes to the document were made in response to this comment.
26-01	07-11-2014	Anne Holt, Chairman, Pedernales SWCD #218		X	The WSEP is an excellent program and should be continued. It is not about brush removal, but about water enhancement. It is based on professional research showing increases in water from creeks and springs feeding into main rivers such as the Pedernales and Guadalupe Rivers.	No changes to the document were made in response to this comment.
26-02	07-11-2014	Anne Holt, Chairman, Pedernales SWCD #218		X	Removal of large stands of juniper along these riparian areas has rejuvenated many springs and water flows longer in these tributaries.	No changes to the document were made in response to this comment.
26-03	07-11-2014	Anne Holt, Chairman, Pedernales SWCD #218		X	Grasses and forbs return to these areas where once only juniper stood. These grasses and forbs prevent erosion, filter groundwater and provide food and habitat for wildlife.	No changes to the document were made in response to this comment.
26-04	07-11-2014	Anne Holt, Chairman, Pedernales SWCD #218		X	The program also reinforces good stewardship of the land and its resources by including grazing deferment. This program continues to teach conservation to both new and seasoned landowners.	No changes to the document were made in response to this comment.

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26-05	07-11-2014	Anne Holt, Chairman, Pedernales SWCD #218		X	There are always new conservation practices and this program focuses on water which is a high priority in the state of Texas.	No changes to the document were made in response to this comment.
27-01	07-11-2014	Bob Brockman, Chairman; Robert Sol Mayer, Vice Chairman; Dean Dermody, Director; Max Howorth, Director; Joe David Ross, Director; Sutton County Underground Water Conservation District		X	The Sutton County UWCD board of directors (Board) voted in favor of a resolution, at its Tuesday July 8, 2014 meeting, supporting the TSSWCB proposed revision of the Plan. The Board recognizes the importance of this program as an ongoing project to enhance available surface and groundwater through selective control of brush species that are detrimental to water conservation.	No changes to the document were made in response to this comment.
27-02	07-11-2014	Brockman, et al.	X		The scope of this project includes: Updating and revising rules to keep pace with changes in provisions of House Bill 1808.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
27-03	07-11-2014	Brockman, et al.		X	We continue to support our local TSSWCB in its efforts to carry out these responsibilities in our area. We look forward to the successful revision of the Plan; and its application within our District.	No changes to the document were made in response to this comment.
28-01	07-11-2014	Marty H. Graham, Chairman; and Board of Directors; Upper Nueces-Frio SWCD #238		X	The Upper Nueces-Frio SWCD #238 supports the TSSWCB's WSEP. Research has been conducted and studies show that when certain species of brush are removed in areas that have certain soil types and topography, water yield is increased during rainfall events.	No changes to the document were made in response to this comment.
28-02	07-11-2014	Marty H. Graham, Chairman; and Board of Directors; Upper Nueces-Frio SWCD #238		X	We are currently participating in a WSEP project and feel that the spatial analysis technology being utilized to determine the best areas to clear brush for water yield is a good approach to implementing brush control.	No changes to the document were made in response to this comment.
28-03	07-11-2014	Marty H. Graham, Chairman; and Board of Directors; Upper Nueces-Frio SWCD #238		X	We also feel that the cost-share incentive allows some landowners the needed funds to conduct the brush control that is so badly needed.	No changes to the document were made in response to this comment.
29-01	07-13-2014	Elizabeth McGreevy		X	I cannot believe why, after all the newest research, the State still believes that removing vast tracts of brush is going to increase our water supplies. It appears to me the real hogs are us, the people, not the trees: http://www.mensjournal.com/magazine/print-view/who-stole-the-water-20140623.	No changes to the document were made in response to this comment. See Preamble.
29-02	07-13-2014	Elizabeth McGreevy		X	I have been researching and providing lectures on the Ashe juniper for over 15 years. I have worked tirelessly to raise people's awareness to realize the tree is not the scourge of civilization it has been made out to be mostly by the media and biased researchers. As I am finishing up my book on the tree, I am awaiting to see the results of your agency.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
29-03	07-13-2014	Elizabeth McGreevy		X	The primary disagreement I have is the proposition that the phrase “brush control” be changed to “water supply enhancement” throughout.	No changes to the document were made in response to this comment. See Preamble.
29-04	07-13-2014	Elizabeth McGreevy		X	And, although I have no problem with removing and thinning brush to manage for wildlife habitat or pasture, the idea that clearing away a bunch of brush will magically create more water is short sighted and misguided.	No changes to the document were made in response to this comment. See Preamble.
29-05	07-13-2014	Elizabeth McGreevy		X	Where is the talk about REAL water supply enhancement such as mulching, swales, depressions, windrows, gabions, remineralization, adding charcoal, etc. that will slow water to allow it to sink deep?	No changes to the document were made in response to this comment. See Preamble.
29-06	07-13-2014	Elizabeth McGreevy		X	And what about old growth trees? Are old-growth mesquite and junipers to be lumped in with juveniles? Perhaps, this is distinguished on a site by site basis, but that's just a “perhaps.” It does mention endangered species habitat in one section. Perhaps it is there that the phrase old-growth should be inserted, since old-growth Ashe junipers serve as primary habitat for an endangered bird.	No changes to the document were made in response to this comment.
29-07	07-13-2014	Elizabeth McGreevy		X	As for the referenced feasibility studies, most use estimates and incomplete and/or improper data collection. For instance, during the follow-up interception studies of Ashe junipers, Dr. Wilcox discovered the rain simulations were being conducted in full sun. Also, it was discovered rain flowing down trunks was not being measured. That's just two examples of incomplete science the public has been taught to take as gospel.	No changes to the document were made in response to this comment.
29-08	07-13-2014	Elizabeth McGreevy		X	In the attached PDF presented to your group by a panel of highly respected scientists [comments from Wilcox et al.], note the inclusion of Dr. Keith Owens. It was his gallons of water per day number he came up with (again, a quick estimate based on one bushy, young juniper growing in full sun), and he has since then shown live oaks use more water. If this is the case, then why are we not including live oaks in the plan?? It makes the State appear biased.	No changes to the document were made in response to this comment.
29-09	07-13-2014	Elizabeth McGreevy		X	I do take issue with the code calling junipers and mesquite noxious. That's extremely strong, opinionated language for trees that are native to Texas. Saltcedar is not. Even still, such strong language is unnecessary.	No changes to the document were made in response to this comment.
29-10	07-13-2014	Elizabeth McGreevy		X	Further, the code classifies junipers as phreatophytes. Junipers have not been proven to be phreatophytes: http://susan-schwinning.net/downloads/Litvak_et_al_2010.pdf.	No changes to the document were made in response to this comment.

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29-11	07-13-2014	Elizabeth McGreevy		X	I propose, if you want to call this section water supply enhancement, then integrate valid land restoration techniques that are actually working. Misleading the public to believe clear cutting brush will magically increase their water flows is misleading.	No changes to the document were made in response to this comment. See Preamble.
30-01	07-14-2014	Dr. Richard E. Zartman, Texas Tech University		X	This Plan follows the basic premise of the hydrologic cycle that water not used by ET is moved into the soil or runs off the soil surface. Movement of water into the soil can recharge groundwater below or be transmitted subsurface laterally to surface water. Water moving across the soil can be intercepted for use by other plants or increase water in a surface waterbody such as a river, stream or lake.	No changes to the document were made in response to this comment.
30-02	07-14-2014	Dr. Richard E. Zartman, Texas Tech University		X	The Plan states that the TSSWCB is to use "...a competitive grant process to rank feasible projects…" Section 4.2 Specific Goal 2 states that this plan will "Direct program grant funds toward acreage within an established project that will yield the most water." The evaluation criteria of "Soils. Slope, Brush Density, Proximity to waterbodies, and Proximity to watershed outlet" seem to be a reasonable and prudent set of parameters to categorize into high, medium, low or not eligible location for selected phreatophytic brush removable.	No changes to the document were made in response to this comment.
30-03	07-14-2014	Dr. Richard E. Zartman, Texas Tech University		X	In conjunction with willing landowners, using the above stated criteria, would be a logical and effective way to select priority areas for implementing water enhancement management programs. This, in conjunction with proper follow-up programs, would insure that areas were properly managed after initial treatment.	No changes to the document were made in response to this comment.
30-04	07-14-2014	Dr. Richard E. Zartman, Texas Tech University		X	I strongly support the concept that eliminating phreatophytic brush species near waterbodies or above rechargeable aquifers would increase available surface and ground water for the state of Texas.	No changes to the document were made in response to this comment.
31-01	07-15-2014	Karnes County SWCD #343, Board of Directors		X	The Karnes County SWCD would like to express our support of the Plan. We appreciate your concern and proactive measures to protect the waters in the great state of Texas. Ensuring that the state continues to protect, maintain, and provide clean water for all of its citizens is a continuing battle; a battle which should be placed in high priority.	No changes to the document were made in response to this comment.
31-02	07-15-2014	Karnes County SWCD #343, Board of Directors		X	By removing and controlling brush, landowners have the ability to improve water quality and yield, and improve soil conservation. We believe it to be beneficial to landowners and coincides with our efforts to improve the soil and water quality.	No changes to the document were made in response to this comment.

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31-03	07-15-2014	Karnes County SWCD #343, Board of Directors		X	We would like for you to consider cost sharing for seeding which will be necessary following mechanical brush management. This will further protect our soil and water after brush has been removed.	No changes to the document were made in response to this comment.
32-01	07-15-2014	Salvador Salinas, Texas State Conservationist, United States Department of Agriculture – Natural Resources Conservation Service		X	The selective removal of woody species on Texas rangelands has the potential to influence water availability when coupled with other essential conservation practices and implemented according to a conservation plan.	No changes to the document were made in response to this comment.
32-02	07-15-2014	Salvador Salinas, Texas State Conservationist, United States Department of Agriculture – Natural Resources Conservation Service		X	Woody species encroachment on Texas rangelands is of major concern to Texas landowners and operators. Woody species encroachment negatively impacts many of the ecosystem services provided by rangelands ranging from reduced forage quantity and quality, degraded wildlife habitat, and impaired stream flow and water quality.	No changes to the document were made in response to this comment.
32-03	07-15-2014	Salvador Salinas, Texas State Conservationist, United States Department of Agriculture – Natural Resources Conservation Service		X	Brush management is typically the initial control method utilized by rangeland managers to address woody species encroachment issues. The most common purposes for planning brush management include 1) Creating a desired plant community consistent with the ecological site, 2) Maintaining, modifying, or enhancing fish and wildlife habitat, 3) Improving forage accessibility, quality and quantity for livestock and wildlife, 4) Managing fuel loads to achieve desired conditions, 5) and improving water quantity and quality.	The document was revised in response to this comment.
32-04	07-15-2014	Salvador Salinas, Texas State Conservationist, United States Department of Agriculture – Natural Resources Conservation Service		X	Brush management provides many positive responses to rangeland processes. Brush management is a facilitating practice applied on the landscape to meet an overall conservation goal or objective such as restoring ecosystem functions, which includes improving the hydrologic function of the ecological site.	No changes to the document were made in response to this comment.
32-05	07-15-2014	Salvador Salinas, Texas State Conservationist, United States Department of Agriculture – Natural Resources Conservation Service		X	Proper grazing management, follow-up brush management treatments, and long term implementation of a conservation plan, which may include other associated and essential conservation practices, are principal tenants in addressing woody species encroachment and ecosystem restoration. Site specific assessments, development of site specific conservation plans, which include brush management and the associated essential conservation practices, can have cumulative impacts that will address hydrologic function and long term rangeland sustainability when applied in a holistic approach.	No changes to the document were made in response to this comment.

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32-06	07-15-2014	Salvador Salinas, Texas State Conservationist, United States Department of Agriculture – Natural Resources Conservation Service		X	Although detailed conservation plans are site specific, the overall program should be assessed at the landscape level, and the focus being conservation implementation in targeted watersheds with specific, realistic and achievable goals to achieve long term ecosystem restoration resulting in improved hydrologic function.	No changes to the document were made in response to this comment.
33-01	07-16-2014	Rickey James, President, Association of Texas Soil and Water Conservation Districts		X	The TSSWCB has administered this program for more than 10 years. We are proud to support the program and the work of the agency.	No changes to the document were made in response to this comment.
33-02	07-16-2014	Rickey James, President, Association of Texas Soil and Water Conservation Districts		X	Research has proven that when specific brush species are removed in areas with certain soil types and topography, water yield increases during rainfall events.	No changes to the document were made in response to this comment.
33-03	07-16-2014	Rickey James, President, Association of Texas Soil and Water Conservation Districts		X	Technology is used to develop specific plans for brush removal that continue to wildlife habitat and increased water yields.	No changes to the document were made in response to this comment.
33-04	07-16-2014	Rickey James, President, Association of Texas Soil and Water Conservation Districts		X	The cost-share provided through the program allows producers to participate in the program who might not otherwise have the resources to participate.	No changes to the document were made in response to this comment.
33-05	07-16-2014	Rickey James, President, Association of Texas Soil and Water Conservation Districts		X	With Texas in the midst of one of the worst droughts in history we need to look at all options available to make the most of our water resources, including water enhancement through brush control. Increased water yields into area streams, rivers, and reservoirs are a benefit to all Texans.	No changes to the document were made in response to this comment.
34-01	07-16-2014	Cristina Campbell		X	I am writing to voice my opposition to the WSEP. As a biologist with a Masters Degree in Conservation and Population Biology the science supporting the claims that brush management, i.e. the cutting down of native trees (juniper and mesquite) as a practice to enhance water quality or quantity, improve soil, and manage for invasive species is erroneous.	No changes to the document were made in response to this comment. See Preamble.
34-02	07-16-2014	Cristina Campbell		X	Contrary to what is stated in the Program Overview, scientists have shown that soil is built from trees. That carbon and nitrogen from senescing leaves feed soil organisms which lead to healthy soils, with a high humic acid. Said humic layer holds 80% more water than sandy soil (soil typified by damaged land in this region of Texas).	No changes to the document were made in response to this comment.
34-03	07-16-2014	Cristina Campbell		X	The transpiration that trees provide adds moisture to the air, helping to create cycles of rain. Further the moisture bank that trees like juniper and mesquite provide, create habitat to establish other plants. Trees provide ecological functions (water filtration, air filtration, and soil creation) that are especially important in our arid region.	No changes to the document were made in response to this comment.

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34-04	07-16-2014	Cristina Campbell		X	Lastly, removing native trees creates disturbed habitat that invasive species thrive in.	No changes to the document were made in response to this comment.
34-05	07-16-2014	Cristina Campbell		X	It is my hope that this inaccurate and flawed program will not go forward.	No changes to the document were made in response to this comment. See Preamble
35-01	07-16-2014	Andy Garza		X	I can recall the days when telling the Rocky Creek story was big news for the Soil Conservation Service in Texas. Brush control was done in the vicinity of a spring that had gone dry. Through brush control and proper range management, the spring started flowing again. Now that was a success story worth telling. I am convinced that this particular event inspired Senator Sims as he and perhaps others wrote the legislation that created the BCP in Texas.	The document was revised in response to this comment.
35-02	07-16-2014	Andy Garza		X	By the way, changing from Brush Control to SWSEP is like rearranging the stripes on a zebra.	No changes to the document were made in response to this comment. See Preamble.
35-03	07-16-2014	Andy Garza		X	The SWSEP is a good program with much potential for Texas. However, the TSSWCB must be very SELECTIVE as to where implementation takes place.	No changes to the document were made in response to this comment.
35-04	07-16-2014	Andy Garza		X	Quantifying the results will be crucial. Find ways to repeat the Rocky Creek story in areas that are predicted to experience water shortages and you will have success.	No changes to the document were made in response to this comment.
35-05	07-16-2014	Andy Garza		X	Normal rainfall patterns would help, too.	No changes to the document were made in response to this comment.
36-01	07-16-2014	Kendall SWCD #216, Board of Directors		X	In regard to the current WSEP, the Kendall SWCD would like to adamantly state our support of this necessary and successful program. We feel this program is doing the job it was created to do.	No changes to the document were made in response to this comment.
36-02	07-16-2014	Kendall SWCD #216, Board of Directors		X	We feel that the condition of deferment built into the program enhances proper grazing of vegetation.	No changes to the document were made in response to this comment.
37-01	07-17-2014	Mark Crider		X	Please register my support for the continuation of the WSEP.	No changes to the document were made in response to this comment.
38-01	07-17-2014	Volney Hough, Director, Upper Nueces-Frio SWCD #238		X	Please register my support for continuation of the WSEP.	No changes to the document were made in response to this comment.
39-01	07-17-2014	Jule Richmond, Chairman, Pecan Bayou SWCD #553		X	Research has proven that when specific brush species are removed in areas with certain soil types and topography, water yield increases during rainfall events.	No changes to the document were made in response to this comment.
39-02	07-17-2014	Jule Richmond, Chairman, Pecan Bayou SWCD #553		X	Technology is used to develop specific plans for brush removal that continue to provide wildlife habitat and increased water yields.	No changes to the document were made in response to this comment.
39-03	07-17-2014	Jule Richmond, Chairman, Pecan Bayou SWCD #553		X	The cost-shared provided through the program allows producers to participate in this program who have land in an area proven through modeling, to yield significant water into waterbodies utilized for human needs.	No changes to the document were made in response to this comment.

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39-04	07-17-2014	Jule Richmond, Chairman, Pecan Bayou SWCD #553		X	Increased water yields into our reservoirs are a benefit to all Texans. Pecan Bayou SWCD is pleased with the focus of the WSEP, and the many benefits to Texas Waters.	No changes to the document were made in response to this comment.
40-01	07-18-2014	Ken Dickson		X	I do think that we do need a water plan. I have a tract in Cass County down in the Sabine watershed, Black Bayou. And I'm concerned a little bit about the requirements of the state getting involved in brush control, because we've sort of avoided any type of government control. However, I do believe very strongly in a strong water plan. I would like to be sure that we don't have anyone that's any type of complication. We've owned that tract since 1917.	No changes to the document were made in response to this comment.
41-01	07-18-2014	Bandera SWCD #229, Board of Directors		X	The Bandera SWCD board members would like to express their positive feelings about the WSEP. This program has been instrumental in removing brush from Bandera County and freeing up water for public and private use. We strongly believe in this very worthwhile program.	No changes to the document were made in response to this comment.
42-01	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	I strongly support TSSWCB's Plan. The Plan is not brush clearing as practiced in the past. While still in the early development and pilot project phases, this watershed enhancement program should not be compared to previous methods of brush removal which primarily focused on improving grazing. There are many important distinctions.	No changes to the document were made in response to this comment.
42-02	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Fully deployed, WSEP could restore approximately 1.5M ac-ft to our State's environmental flows, lakes, aquifer recharge, bays and estuaries annually. This conserved water supply is essential to reduce Texas' projected 8.25M ac-ft water deficit and meet municipal, agricultural and power and industrial needs.	No changes to the document were made in response to this comment.
42-03	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Only now is watershed restoration mapping and measurement technologies, methodologies and equipment available for beneficial water supply enhancement which offers a financially viable alternative to past brush clearing methods and programs. Continuing to meet existing and future demands for water in our State with our declining existing supplies is not feasible. Many believe current surface and groundwater supplies are stretched to the limit.	No changes to the document were made in response to this comment.

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42-04	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Today literally millions of ac-ft of water in Texas are lost to evaporation and ET (use by plants, many of them non-beneficial). In addition, focused watershed restoration can both foster aquifers refilling more quickly and enhance instream and environmental flows. In a world where every drop counts, we can economically add to our existing supplies using new and proven watershed mapping and brush remediation technologies, especially in semi-arid areas.	No changes to the document were made in response to this comment.
42-05	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	As a fifth-generation Texan experienced in water development, brush remediation and ranching along with Texas partners who are experts in large water project construction and watershed restoration technologies, we are concerned about the future of our state. As a participant with private landowners in the WSEP project, I want to thank the TSSWCB for allowing me to share my thoughts and comments.	No changes to the document were made in response to this comment.
42-06	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Given time to develop and appropriate funding, WSEP will continue to improve grazing but as required in today's voting environment provide significant funding for new regional water supplies and a natural bridge between urban and rural interests that also addresses: Wildfire management and control; Wildlife habitat enhancement; Recreational opportunities; Border security; Improved property values; New economic development; Reduction of emissions via biomass; Long term job creation; New industries statewide; and Strong landowner participation.	No changes to the document were made in response to this comment.
42-07	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Heavily influenced by urban regions, consulting firms and scientists, the Texas Water Plan document focuses on existing supplies and development of a variety of strategies. The Texas Water Plan is the result of research, documentation and planning produced by many local, regional and state planning groups and planning group members. However, our State Water Plan has given little consideration to creating new water resources by economically reducing significant water losses to evaporation or ET. TSSWCB's WSEP helps address this critical short coming while retaining decision-making at the SWCD and landowner level.	No changes to the document were made in response to this comment.

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42-08	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	New sciences and methodologies help identify and map critical restoration opportunities on brush covered watersheds to divert new or developed water into depleted springs, rivers, lakes and aquifers to confine, protect, bank, manage and recover water supplies which would normally be lost to evaporation or ET. In addition to providing much needed economic development for rural communities, new brush clearing methods, equipment and GPS controls minimize erosion, rapidly restore ground cover vegetation and enhance water restoration for use by both urban and rural beneficiaries.	No changes to the document were made in response to this comment.
42-09	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	As an ongoing TSSWCB program in partnership with private landowners, WSEP experience and research into watershed restoration will comply with legislative requirements to move our State from funding brush clearing solely for individual landowner's benefit to a significantly increasing funding for a statewide program of watershed restoration and water supply enhancement.	No changes to the document were made in response to this comment.
42-10	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	While each landowner will continue to benefit, Texas taxpayers should readily agree to long-term funding because WSEP also: Increases wildlife habitat; Helps manage flooding; Increases base water flow; Protects riparian areas; Enhances water quality; Reduces or minimizes erosion; Improves land productivity; Sustains aquatic habitat; Increases aquifer recharge; and Provides new environmental flows.	No changes to the document were made in response to this comment.
42-11	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	The Texas Wildlife Association (TWA) is an important representative of thousands of landowners and millions of acres throughout our State. I fully agree with Greg Simons comment that "We must minimize mistakes as we continue to look for ways to refine conservation practices relating to water abundance and water quality."	No changes to the document were made in response to this comment.
42-12	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	I support Mr. Simons' request "that a 90 day extension be granted on the comment period."	No changes to the document were made in response to this comment.

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42-13	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	I fully agree with three statements another commenter submitted: 1. "We agree that Texas faces very serious water supply challenges in the future, particularly during the inevitable drought periods." 2. "We agree that extensive portions of the State that once were grasslands and savannas are now woodlands." 3. "We agree that managing brush or woody plants potentially provides many benefits – including increased forage production, richer biodiversity improved wildlife habitat, and rejuvenation of small springs. For these reasons, brush management is an indispensable practice on Texas rangelands."	No changes to the document were made in response to this comment.
42-14	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	This commenter and others have cited the previous North Concho River brush clearing project as a failed example of water supply enhancement. I believe that the North Concho River brush clearing project was a transition project but is not a truly viable comparison to watershed restoration mapping and brush remediation methodologies available today and required under WSEP. Although early SWAT model technology was employed for post project monitoring of this brush clearing project, it is my understanding that the landowners selected the brush clearing areas with minimal SWAT input. I also understand that following on previous brush clearing programs, minimal or no requirements were employed as to revegetation, erosion control or long-term brush management. Unlike the current WSEP project through which TSSWCB addresses these short comings, the North Concho River brush clearing project appears to have enhanced grazing opportunities but fell short of requirements necessary to produce water supply enhancement regionally. I believe much was learned from that project.	No changes to the document were made in response to this comment.

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42-15	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	We employ scientists and experts to evaluate and develop our methodologies and we are aware that many of the studies for enhancing aquifer recharge or spring flow indicate brush clearing is non-beneficial for restoring water. This finding is because these studies focused on direct infiltration of water at the site of brush removal. Often such a study involves a quarter of an acre or some other relatively small brush clearing project to produce scientific data without consideration of the overall scale of the watershed, slope, soil characteristics, revegetation or the study site's relationship to recharge structures. Lack of inclusion of location and other factors along with the multiple variables associated with Texas range conditions and weather predetermine a negative finding for direct infiltration.	No changes to the document were made in response to this comment.
42-16	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Certainly some beneficial infiltration and grazing enhancement is achieved but significant regional water supply enhancement by direct infiltration would be difficult to verify through such limited studies.	No changes to the document were made in response to this comment.
42-17	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	We are expert at locating and restoring aquifer recharge, storage and recovery. Location is everything and Texas is blessed that every river and many creeks run across a recharge outcrop of one or more of our aquifers. At these critical intersections nature provides large-scale opportunity for regional infiltration of water. Therefore we believe the greatest value of a long-term WSEP project is encouragement of enhanced water runoff in proximity to aquifer recharge by enhancing rangeland and watersheds to create measurable and quantifiable water supplies for environmental flows. While possibly requiring some modification of WSEP's Ranking Index, reducing water lost to non-beneficial ET and then increasing runoff to a predetermined beneficial location is key. Properly developed, participating private landowners benefit directly but help restore the natural cycle to reduce our State's water deficit by banking water when it is plentiful and benefit taxpayers with that storage in time of need!	No changes to the document were made in response to this comment.
42-18	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	While I believe that increase of brush cover has naturally derogated our rangelands, I also believe that older methods of indiscriminant brush clearing often further derogated the land. Proper long-term implementation of techniques developed through WSEP provides opportunity to reverse rangeland degradation while increasing natural water supplies statewide at minimal expense.	No changes to the document were made in response to this comment.

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42-19	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Watershed restoration programs conducted on, and with the approval of, private landowners should differ from previous government programs in that WSEP provides additional funds and incentives to guarantee that rangeland is replanted or encouraged to recover in beneficial, low-transpiration grasses and landowners are incentivized to "keep the brush off."	No changes to the document were made in response to this comment.
42-20	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Low water enhancement of the overall North Concho River brush clearing project may have demonstrated that typically in any given watershed only 15% to 30% of the rangeland is suitable for brush remediation to restore regional water. Therefore WSEP funding should be limited to larger selected projects. Also, only pristine rangeland should be considered to avoid the introduction of pollutants into the water system.	No changes to the document were made in response to this comment.
42-21	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Experts in hydrology, soil sciences, botany, biology, wildlife, rangeland management, wildfire control and archeology should be involved in creating a brush sculpting and revegetation plan for approval by the landowner.	No changes to the document were made in response to this comment.
42-22	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Properly implemented, the clarified, or possibly new, statewide legislation or policy developed through WSEP could create workable solutions for growing concerns by: Providing new incentives for landowners, water restorers, river authorities and local GCDs to reduce evaporation and ET and to create and harvest new crops of water on private and state lands as needed to increase spring flows, instream and environmental flows, and groundwater levels.	No changes to the document were made in response to this comment.
42-23	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Properly implemented, the clarified, or possibly new, statewide legislation or policy developed through WSEP could create workable solutions for growing concerns by: Providing new incentives and protections for holders of over-appropriated surface water rights which may be lost to evaporation and ET to restore, divert and bank that water in aquifers, thereby converting those surface water rights that may be lost into quantifiable, protected and managed senior groundwater rights.	No changes to the document were made in response to this comment. See Preamble.
42-24	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Properly implemented, the clarified, or possibly new, statewide legislation or policy developed through WSEP could create workable solutions for growing concerns by: Providing new incentives, protections and quantifiable or certified non-curtailable groundwater rights for municipal and urban areas to draw upon during time of drought, water emergency or peak demand.	No changes to the document were made in response to this comment. See Preamble.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
42-25	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Properly implemented, the clarified, or possibly new, statewide legislation or policy developed through WSEP could create workable solutions for growing concerns by: Reducing tensions between rural landholders or GCDs and urban water users while creating new jobs, sustainable economic development and providing millions of ac-ft of new, sustainable and quantifiable water reserves for Texas.	No changes to the document were made in response to this comment.
42-26	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	I encourage consideration of water policies and funding mechanisms that support restoration of surface water and encourage brush management designed to restore water runoff for aquifer recharge, spring flows, and instream or environmental flows. The ability to substantially increase water supply by utilization of new mapping technologies, critical measuring and monitoring methods and skillfully conducted brush clearing with highly-productive specialized equipment while minimizing erosion is now available as a new tool to help reverse our diminishing water supply.	No changes to the document were made in response to this comment.
42-27	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	I commend the TSSWCB and its SWCDs for their leadership and stand ready to work with you, other interested parties and the appropriate Texas agencies such as the TPWD or the TFS to demonstrate and refine feasible approaches to integrating watershed restoration into our State Water Plan.	No changes to the document were made in response to this comment.
42-28	07-21-2014	John Brocksch, CEO, Aquifer Group, LLC		X	Working together to implement and improve WSEP technologies, we can create long-term, economical and sustainable new water for drought management, water emergencies and peak water demands, while contributing to instream and environmental flows. This approach helps to serve both rural and urban water needs, job creation, environmental sustainability and economic development throughout our great State.	No changes to the document were made in response to this comment.
43-01	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	With partners including the South Llano Watershed Alliance, TWRI and many local ranchers, county judges, mayors and other stakeholders, we are developing an Upper Llano Watershed Protection Plan funded through the TSSWCB. Invasive brush (cedar, mesquite, and live oak in some locations) was identified by stakeholders as the major threat to the health of the Upper Llano Watershed.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
43-02	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	I have had the opportunity review some of the pro and con arguments related to the WSEP and administrative procedures to meet required statutory provisions of HB1808 Sunset Implementation. I found it surprising that some ecologists would take such a narrow perspective and view for such a complex ecosystem level topic over such a broad climatic, geographic, edaphic and biological landscape. As a scientist, in the past, when I have encountered such diametrically opposed scientific "findings" I can only conclude that the science is unsettled. This means there is more work to be done.	No changes to the document were made in response to this comment.
43-03	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	For decades, I have told my students the most common answer to a complex ecological question is, "it depends". So I was delighted to read on page 30 of the plan, the many "it depends" factors affecting expectation of water relations associated with brush control.	No changes to the document were made in response to this comment.
43-04	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	The WSEP as it now stands is a significant improvement over previous iterations. The goals, criteria, rankings and priority area designations provide very clear a-priori testable hypotheses and assessment ability. Hopefully, these will be tested against the many factors from page 30.	No changes to the document were made in response to this comment.
43-05	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	I think it also important to note, back in the 1970s the National Science Foundation came to the realization they were not properly funding ecological studies, most project were funded for 3 years. Ecological time scales for responses, especially at larger spatial scales, operate over much longer periods - thus the Long Term Ecological Research program was developed. The WSEP should consider longer and larger spatial scales for research and evaluation of brush control/water supply.	No changes to the document were made in response to this comment.
43-06	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	There is an old ecology adage in poor grammar that captures, in my opinion, a major short-coming of the WSEP, the saying, "you can't do just one thing". As some of the criticisms focused on narrow criteria (runoff), so does the WSEP focus solely on water supply in the short-term. There is a broad array of ecosystem services accrued by managing rangeland for invasive brush. These services include wildlife habitat, recreation (including that associated with wildlife), watershed functions, carbon sequestration, biodiversity conservation, restore desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality, and enhance stream flow, improve forage accessibility, quality, and quantity for livestock, and protect life and property from wildfire hazards.	The document was revised in response to this comment.

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43-07	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	Torell, McDaniel and Ochoa (2005) have noted that if brush control projects are to be profitable expenditures of public funds then the unmeasured benefits of ecosystem services to non livestock entities must exceed the state, county, or federal subsidies necessary to induce livestock producers' participation in brush control programs. Costanza et al. (2014) just came out with a new value for total global ecosystem services at $125 trillion/yr.	The document was revised in response to this comment.
43-08	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	To fully evaluate the benefits/costs and net value of brush control and WSEP, a more holistic and comprehensive economic valuation is required and necessary.	No changes to the document were made in response to this comment.
43-09	07-21-2014	Dr. Thomas L. Arsuffi, Texas Tech University		X	There is also great need to validate the model priority area projections/hypotheses after brush sculpting by hydrological, groundwater, infiltration, ET, agricultural and natural resource economic analyses and studies integrated among disciplines and over sufficient time scales.	No changes to the document were made in response to this comment.
44-01	07-21-2014	Jason Dunsmore		X	Section 2.1 describes most of Texas rangelands as grassland or open savanna, but this is a disputed fact. There are numerous references in the literature to dense cedar thickets going all the way back to 1756. See Table 1 from http://texnat.tamu.edu/library/symposia/juniper-ecology-and-management/holistic-perspective-on-juniper./	No changes to the document were made in response to this comment.
44-02	07-21-2014	Jason Dunsmore		X	It is crucial that every landowner does their own small-scale feasibility study before implementing any of the recommended brush clearing on a larger scale. Every site is unique and it would be nearly impossible for the Plan to account for all of the environmental factors that a landowner will have to consider.	No changes to the document were made in response to this comment.
44-03	07-21-2014	Jason Dunsmore		X	Before scaling up the brush removal on an individual plot of land, there should be at least a year of observation before the treatment and 3 years of observation after treatment in one or more sites that are representative of the larger area being considered for treatment. Plants and animals in the area and their response to the change should be carefully monitored and recorded. At the end of the study, changes to the soil, fauna, and flora should be noted, after which a determination can be made as to whether or not the larger scale brush removal would be beneficial. This feedback loop will help avoid many unforeseen ecological disasters.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
44-04	07-21-2014	Jason Dunsmore		X	In conclusion, a more careful approach is needed in order to avoid a large-scale ecological disaster, the effects of which may not be fully realized or understood for many years. Water conservation and greywater reuse programs have huge untapped potential in Texas with none of the risk.	No changes to the document were made in response to this comment. See Preamble.
45-01	07-21-2014	Kent Ferguson		X	I think this has a huge impact on the future of Texas. Texas is rapidly gaining population and with this comes more demand on our natural resources. Water is the life blood for Texas and it is imperative that we have a good plan in place that will continue wise use and protection for this precious resource. Good resource management in combination with water development projects and improved weather conditions will accomplish these goals for Texas.	No changes to the document were made in response to this comment.
45-02	07-21-2014	Kent Ferguson		X	I have been associated with natural resource management for 37 years and have seen what good resource management plans can do when they are carried out and implemented properly. One practice cannot correct a problem. Ecologic, as well as hydrologic, restoration of rangelands needs to contain a combination of practices that must be applied to the landscape and entire watershed to achieve such a monumental task.	No changes to the document were made in response to this comment.
45-03	07-21-2014	Kent Ferguson		X	I have worked in every part of Texas and can tell you that not all landscapes will respond with the same results. Geology and soils have a tremendous impact on the degree of success when dealing with rangeland restoration.	No changes to the document were made in response to this comment.
45-04	07-21-2014	Kent Ferguson		X	I have observed brush management applied to thousands of acres of land in many different parts of our state and without supporting practices like range seeding, prescribed grazing, and others applied as a follow-up and cooperation from Mother Nature it is often a fruitless effort.	No changes to the document were made in response to this comment
45-05	07-21-2014	Kent Ferguson		X	I would like to emphasize that a comprehensive management plan must be applied in a timely manner to obtain satisfactory results.	No changes to the document were made in response to this comment.
45-06	07-21-2014	Kent Ferguson		X	I support the effort that the TSSWCB has put into developing the Plan.	No changes to the document were made in response to this comment.
45-07	07-21-2014	Kent Ferguson		X	As you are aware, Mother Nature has to play a key role in this scenario and without adequate precipitation the restoration of rangelands and the hydrologic function of these lands can take many years. We must be prepared to do all we can to ensure the sustainability of our natural resources.	No changes to the document were made in response to this comment.

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45-08	07-21-2014	Kent Ferguson		X	Our leadership must plan for the future and get this process in place as time is running out. Texas is in some form of drought more times than not and with increasing population and more pressure being put on our resources we must do everything within our power to keep the natural resources of Texas secure for generations to come. I know that the people you work with and our conservation agencies share this goal and belief and will make sure this happens.	No changes to the document were made in response to this comment.
46-01	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	On behalf of HCA and our Land Practices team, I would like to express our appreciation of your willingness to discuss the Plan. We appreciate the time and effort that you and your colleagues have put into soliciting public feedback and making a good faith effort to respond to the issues that are being raised.	No changes to the document were made in response to this comment.
46-02	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	We have several concerns about the Plan as written. We fear that a focus on increasing water yield measured through runoff enhancement encourages projects that degrade the landscape and over-all health of the water catchment area.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
46-03	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	Without clear restoration requirements, mandates for responsible clearing and consideration of the holistic function of the environment, there can be little guarantee of functioning plant communities in the aftermath of brush clearing work.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
46-04	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	The studies cited in the plan emphasize that the greater the percentage of brush removed, the greater the water yield. The problem, as we perceive it, is that this plan will generate project proposals that leave little vegetation in the project site, have no plans to limit erosion during restoration, and ultimately result in the complete degradation of the landscape to maximize runoff.	No changes to the document were made in response to this comment. The TSSWCB is the state agency responsible for preventing and abating agricultural and silvicultural nonpoint sources of water pollution and the agency's WSEP is designed to reinforce that mission.
46-05	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	We have numerous suggestions for improvements to the plan. While the following ideas are not meant to be an exhaustive list of our recommendations, they show the depth and breadth to which we have considered your plan and committed our time and energy to devising possible solutions.	No changes to the document were made in response to this comment.

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46-06	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	Safeguards. Although it was mentioned that environmental safeguards are put in place through the Conservation Plan for any given project, we believe that there are several mandated safeguards that could be applied universally to all projects, and should be listed up front in the WSEP. These include, but are not limited to, riparian and upland buffers, the use of native grass species in all restoration efforts, deferred grazing requirements, limits on the extent of disturbance and assessment for proper stream function before, during and after brush clearing work.	No changes to the document were made in response to this comment.
46-07	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	Stewardship. The TSSWCB has demonstrated a commitment to land stewardship, including key concepts such as the benefits of lands where “the rainfall soaks into the ground as opposed to running off and carrying soil and sediment.” (“Land Stewardship: Providing Water for Texans,” TSSWCB). We would like to see this same sentiment expressed in the WSEP: land that is managed as a water ‘catchment’ – in which rainwater can slowly infiltrate through healthy plant systems with robust root infrastructure – is much preferable to land that is managed to enhance runoff.	No changes to the document were made in response to this comment.
46-08	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	Holistic Accounting of Water Resource Gains. Runoff is not the only measure of rainwater in a system. We ask that the TSSWCB continue to improve its metrics for measuring holistic ecosystem service improvements that result from responsible brush control, restoration and management. Additional metrics could include soil moisture, stream health and function, infiltration and plant diversity.	No changes to the document were made in response to this comment.
46-09	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	Education and Monitoring. The TSSWCB has a wealth of experience through its years of implementing brush control. We would like to see a commitment to monitor the results of these taxpayer-funded projects and share that information with the public. It is important that those results inform future efforts by not only the TSSWCB, but also by landowners and land managers across the state.	No changes to the document were made in response to this comment.
46-10	07-21-2014	Katherine Romans, Program Manager, Hill Country Alliance		X	We respectfully ask that you extend additional time to work through these issues carefully. With the combined expertise of your staff, HCA and our Land Ethic Team members, we are confident that substantial improvements can be made to this program, which will in turn lead to applications that focus on responsible management and environmentally resilient land systems.	No changes to the document were made in response to this comment.

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47-01	07-21-2014	Znobia Wootan, President, South Llano Watershed Alliance		X	We feel that the Plan (2014) is well intentioned, particularly in regards to the many benefits potentially accrued from brush management. However, ecosystems are very complex and a one-size-fits-all approach is ill advised.	No changes to the document were made in response to this comment.
47-02	07-21-2014	Znobia Wootan, President, South Llano Watershed Alliance		X	Additionally, we feel that the goal of any approach should seek to maximize infiltration and recharge. This will result in increased, long-term base flow as well as benefits for improving the quality of habitats, increasing biodiversity and ecological resiliency. Conversely, outcomes that maximize runoff may not even yield short-term gains, but certainly will result in natural resource degradation through erosion and drying of landscapes. Erosion and drying will reduce the capacity of a watershed to sustain ecosystem health and yields a net reduction in base flow.	No changes to the document were made in response to this comment.
47-03	07-21-2014	Znobia Wootan, President, South Llano Watershed Alliance		X	We hope that the TSSWCB will carefully consider the many opinions generated by the Plan and be open to improved revisions.	No changes to the document were made in response to this comment.
48-01	07-21-2014	Glen Lyon, Chairman, Cochran SWCD #149		X	The TSSWCB has administered this program for more than 10 years. We are proud to support the program and the work of the agency.	No changes to the document were made in response to this comment.
48-02	07-21-2014	Glen Lyon, Chairman, Cochran SWCD #149		X	Research has proven that when specific brush species are removed in areas with certain soil types and topography, water yield increases during rainfall events.	No changes to the document were made in response to this comment.
48-03	07-21-2014	Glen Lyon, Chairman, Cochran SWCD #149		X	Technology is used to develop specific plans for brush removal that continue to provide wildlife habitat and increased water yields.	No changes to the document were made in response to this comment.
48-04	07-21-2014	Glen Lyon, Chairman, Cochran SWCD #149		X	The cost-share provided through the program allows producers to participate in the program who might not otherwise have the resources to participate.	No changes to the document were made in response to this comment.
48-05	07-21-2014	Glen Lyon, Chairman, Cochran SWCD #149		X	With Texas in the midst of one of the worst droughts in history we need to look at all options available to make the most of our water resources, including water enhancement through brush control. Increased water yields into area streams, rivers, and reservoirs are a benefit to all Texans.	No changes to the document were made in response to this comment.
49-01	07-21-2014	Mark Grijalva, Chairman, El Paso-Hudspeth SWCD #205		X	Out here in the arid parched west Texas desert we have seen firsthand the benefits of the WSEP. Our SWCD #205 in El Paso and Hudspeth counties sincerely appreciates this cost-share program and the hard work of your agency to make this program a reality.	No changes to the document were made in response to this comment.

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49-02	07-21-2014	Mark Grijalva, Chairman, El Paso-Hudspeth SWCD #205		X	In the Cattle Ranches out here it's awesome to see old springs come back to life and provide water for cattle - just because unneeded specific brush species are removed. And I need to mention that the cattle are safer because predators can't easily hide behind this same brushes. Grasses from seed develop faster and thrive after desert rainfalls simply because shade is not a factor and the grasses aren't competing with brushes for water. But most importantly - the water table benefits the most, because heavily water drinking brushes are removed and not absorbing precious water after minimal desert rainfalls.	No changes to the document were made in response to this comment.
49-03	07-21-2014	Mark Grijalva, Chairman, El Paso-Hudspeth SWCD #205		X	One more example is a single adult saltcedar brush can absorb an ac-ft of water. And the Pecos River is a prime example of the benefits of this program. With the removal of these thirsty saltcedar brushes along the River and arroyos. The River is not robbed of minimal rainfall and delivers more water to Lake Amistad in Del Rio because of this.	No changes to the document were made in response to this comment.
49-04	07-21-2014	Mark Grijalva, Chairman, El Paso-Hudspeth SWCD #205		X	In short, we are proud to support this program and the hard work of the agency.	No changes to the document were made in response to this comment.
50-01	07-21-2014	Coastal Plains SWCD #317, Board of Directors		X	As we become more populated each year, water becomes a more limited and valuable resource and we realize the importance and the need to conserve this precious commodity. It is very much necessary to maintain our rivers and streams by controlling noxious brush that may interfere with water conservation, thus allowing us to increase our available surface and ground water. This is why we feel that the Plan is a great plan for a program that will benefit all areas and people concerned, including rural, as well as, urban communities; therefore, we highly recommend funding for this program.	No changes to the document were made in response to this comment.
51-01	07-21-2014	Ronny Petty, Chairman; Mac Wilmeth, Vice Chairman; Iven Neal, Director; Jill Beever, Director; Frio SWCD #325		X	Four Directors are "For" the Plan.	No changes to the document were made in response to this comment.
52-01	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346		X	We are in agreement with the concept of cost-share treatments for brush control fur water enhancement. Since watershed treatments benefit all residents the public should assist in paying for treatments to enhance water yield. Our SWCD board members have made a few suggestions to make the program more effective and usable.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
52-02	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346	X		Section 517.26 The concern is the Science Advisory committee will be the sole entity in deciding Water Enhancement Project funding. Participation from knowledgeable entities with the scope of the projects should also be sourced and considered.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
52-03	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346	X		Section 517.23 – Definitions (26) Thought should be given to the 10 year contract length. Term should be reduced to 5 years or less. Follow up treatment should occur within 3 years of initial treatment Therefore, making a 10 year contract impractical.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
52-04	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346	X		Section 517.25 Data used in modeling determines effectiveness. Modeling without verified data is suspect.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
52-05	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346	X		Section 517.36(a) contract length 2-5 years	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
52-06	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346	X		Section 517.36(b)(3) There is no technology or methodology available to achieve a lasting 95% kill or canopy reduction on any brush control project.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
52-07	07-21-2014	Stephen Diebel, Chairman, Victoria SWCD #346	X		Section 517.36(g) Plan must provide for more than one treatment for cost-share on a given area.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
53-01	07-21-2014	Jay Bragg, Texas Farm Bureau		X	Texas Farm Bureau supports programs to improve water conservation and water quality including the removal and control of non-beneficial/non-productive brush species that consume or impede water flow in our streams, ponds, lakes and estuaries.	No changes to the document were made in response to this comment.
53-02	07-21-2014	Jay Bragg, Texas Farm Bureau		X	Texas Farm Bureau also supports brush control programs that are positive for range, wildlife and livestock management and benefit diversity of flora and fauna and water conservation.	No changes to the document were made in response to this comment.
53-03	07-21-2014	Jay Bragg, Texas Farm Bureau		X	In 2011, the Legislature redirected the focus of the TSSWCB's BCP. HB1808 renamed the program the WSEP and required that funding be dedicated for the purpose of public benefit. While Texas Farm Bureau supports brush control programs for the purpose of rangeland improvement and wildlife habitat enhancement, the legislature did not re-authorize the program for these purposes.	No changes to the document were made in response to this comment.

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53-04	07-21-2014	Jay Bragg, Texas Farm Bureau		X	TFB acknowledges that brush control is a viable conservation practices and can enhance water availability. In order to continue the program, it must be implemented in a meaningful and deliberate way that quantifies the benefits of the program.	No changes to the document were made in response to this comment.
53-05	07-21-2014	Jay Bragg, Texas Farm Bureau	X		The proposed rule appears to reflect the legislative intent of HB1808 and strives to maximize available resources. As such, Texas Farm Bureau supports the proposed changes to the program.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
53-06	07-21-2014	Jay Bragg, Texas Farm Bureau	X		We would, however, encourage the TSSWCB to evaluate the proposed rule to ensure the program will continue to benefit landowners as well as the general public. Failure to do so will result in decreased interest/support for the program.	No changes to the document were made in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.
54-01	07-21-2014	Pete Bonds, President, Texas and Southwestern Cattle Raisers Association		X	TSCRA appreciates the opportunity to comment on the Plan. TSCRA supports BMPs on range and pasture lands that will reduce and/or eliminate invasive brush species, while also preventing soil erosion.	No changes to the document were made in response to this comment.
54-02	07-21-2014	Pete Bonds, President, Texas and Southwestern Cattle Raisers Association		X	TSCRA supports the Plan and its intention to selectively control brush species that are detrimental to water conservation in an effort to increase available surface and ground water.	No changes to the document were made in response to this comment.
54-03	07-21-2014	Pete Bonds, President, Texas and Southwestern Cattle Raisers Association		X	TSCRA values the long-standing partnership it has with the TSSWCB and the work that has been done so far for water supply enhancement throughout Texas.	No changes to the document were made in response to this comment.
55-01	07-21-2014	Cameron Turner, Texas Water Development Board	X	X	It is my understanding from discussions / presentations from TSSWCB staff and the current solicitation for WSEP projects, that individual project eligibility under this program is contingent upon the appropriate regional water plan containing brush control as a water management strategy. If this is correct, you might consider including this specific requirement in the rules. There is currently only brief mention of considering a “need for conservation of water resources… in the state water plan.” I find no other reference to the water plan(s).	The document was revised in response to this comment. This comment will be considered in the proposed amendments to 31 TAC Chapter 517, Subchapter B.

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56-01	07-21-2014	Dr. Kevin Wagner, Associate Director, Texas Water Resources Institute, Texas A&M AgriLife Research		X	The State WSEP and the financial assistance it provides to landowners yield numerous benefits to Texans and the State's natural resources. Removal of invasive brush through this program has returned many historic grassland prairies to a more natural state. With proper management and utilization, watershed health and function is often improved in these areas resulting in increased forage production for livestock, enhanced habitat for wildlife, improved water quality, and localized improvements in water resource availability.	No changes to the document were made in response to this comment.
56-02	07-21-2014	Dr. Kevin Wagner, Associate Director, Texas Water Resources Institute, Texas A&M AgriLife Research		X	Brush control is not inexpensive, and the area of land in Texas that could benefit from this practice is great. Thus, the need to refine where limited funds are utilized is also great. The proposed revisions to the Plan outline positive additions to the program that will facilitate improved fund utilization once implemented.	No changes to the document were made in response to this comment.
56-03	07-21-2014	Dr. Kevin Wagner, Associate Director, Texas Water Resources Institute, Texas A&M AgriLife Research		X	In this age of readily available information, utilizing this knowledge to make informed decisions is wise. Including 'geospatial analysis for prioritizing acreage eligible for cost-share' is a step in the right direction that will improve the prioritization process.	No changes to the document were made in response to this comment.
56-04	07-21-2014	Dr. Kevin Wagner, Associate Director, Texas Water Resources Institute, Texas A&M AgriLife Research		X	An additional suite of characteristics that should be considered in this prioritization metric are climatic factors such as rainfall (average annual amount, storm intensity and duration, timing within the year) and ET. With increased water yield being the goal of the program, including these factors in the prioritization process is critical.	No changes to the document were made in response to this comment.
56-05	07-21-2014	Dr. Kevin Wagner, Associate Director, Texas Water Resources Institute, Texas A&M AgriLife Research		X	Ecosystem services provided by the State WSEP are of great benefit to Texans and range from on-site benefits where the brush is actually removed to downstream benefits. Science driven measures to improve the effectiveness and application of this program throughout Texas are strongly supported.	The document was revised in response to this comment.
57-01	07-21-2014	Chuck Brown, Upper Colorado River Authority		X	Previous research conducted by our office indicates that without a doubt, brush control is a valuable tool in water conservation. As you are aware, UCRA's latest ET study in the North Concho River watershed in northern Tom Green County quantified approximately 20,000 gal/ac/yr in water saved through brush control. That is a significant amount when applied to a watershed scale.	No changes to the document were made in response to this comment.

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57-02	07-21-2014	Chuck Brown, Upper Colorado River Authority		X	These test plots were performed on upland mesquite sites with light to moderate densities. Therefore, it is safe to assume that brush control in prioritized areas and along riparian corridors would conserve a much greater amount of water than previous studies have indicated.	No changes to the document were made in response to this comment.
57-03	07-21-2014	Chuck Brown, Upper Colorado River Authority		X	In conclusion, we fully support the efforts of the TSSWCB WSEP and its efforts to conserve and enhance the availability of water supplies for Texas.	No changes to the document were made in response to this comment.
58-01	07-21-2014	Dr. Jeffrey G. Arnold, Grassland Soil and Water Research Laboratory, United States Department of Agriculture – Agricultural Research Service		X	The SWAT model is the result of a 25 year, coordinated effort of USDA-ARS, NRCS, Texas A&M and numerous organizations around the world. SWAT is a dynamic and highly flexible tool developed to quantify and predict the impacts of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time. There are over 1,700 articles in the peer reviewed literature describing SWAT development, validation and assessment (https://www.card.iastate.edu/swat_articles/).	No changes to the document were made in response to this comment.
58-02	07-21-2014	Dr. Jeffrey G. Arnold, Grassland Soil and Water Research Laboratory, United States Department of Agriculture – Agricultural Research Service		X	SWAT is the watershed scale model used In the CEAP (Conservation Effects Assessment Project) National Assessment for Cropland is to estimate the environmental benefits and effects of conservation practices applied to cultivated cropland and cropland enrolled in long-term conserving cover. In addition, it is the engine for the Hydrologic and Water Quality System, or HAWQS, an EPA national water quality modeling system that integrates the latest environmental data with state-of-the-art computer technology to evaluate the impacts of management alternatives, pollution control scenarios, and climate change scenarios on the quantity and quality of water at a national scale.	No changes to the document were made in response to this comment.
58-03	07-21-2014	Dr. Jeffrey G. Arnold, Grassland Soil and Water Research Laboratory, United States Department of Agriculture – Agricultural Research Service		X	SWAT considers a complete water balance for multiple fields within a watershed and then routes flow and constituents through rivers, flood plains and reservoirs to the watershed outlet. The water balance includes routines for surface runoff, groundwater flow, ET, soil water routing, and has a detailed, mechanistic plant growth model that simulates leaf area, root growth and biomass development throughout the growing season.	No changes to the document were made in response to this comment.

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58-04	07-21-2014	Dr. Jeffrey G. Arnold, Grassland Soil and Water Research Laboratory, United States Department of Agriculture – Agricultural Research Service		X	It has been applied to brush control studies in the past and shown positive impacts on water yield. The model has been extensively validated with respect to land use change (138 peer reviewed articles) and specifically to brush control (3 peer reviewed articles and a report on "Brush Management/Water Yield Feasibility Studies for Eight Watersheds in Texas" - TWRI Tech. Report 182).	No changes to the document were made in response to this comment.
58-05	07-21-2014	Dr. Jeffrey G. Arnold, Grassland Soil and Water Research Laboratory, United States Department of Agriculture – Agricultural Research Service		X	We are pleased that SWAT has been recommended and are confident it will provide science-based insight to aid in the decision making process.	No changes to the document were made in response to this comment.
59-01	07-21-2014	Dr. Jason West, Texas A&M University		X	I also appreciate the extension of the deadline since travel and other obligations have prevented me from commenting before now.	No changes to the document were made in response to this comment.
59-02	07-21-2014	Dr. Jason West, Texas A&M University		X	I have conducted some initial research very recently in south Texas on plant water use, impacts of brush removal on soil moisture, and potential implications for groundwater, and in other projects studied interactions between vegetation and surface water, also in south Texas. I have fairly extensive experience, in general, with plant water use, soil characteristics that affect soil moisture availability, and other topics related to the proposed Plan. I therefore believe I have expertise relevant to the proposal.	No changes to the document were made in response to this comment.
59-03	07-21-2014	Dr. Jason West, Texas A&M University		X	It is clear that Texas has significant challenges with respect to water availability and that they are likely to become increasingly difficult as the population of Texas grows. Thus it is rational for state agencies, private landowners, industrial and corporate interests, universities and other research entities, and federal agencies to be focused on how this challenge may be managed and what options may exist or may be developed to address it. The TSSWCB and its advisors and collaborators clearly play a key role in water conservation and land management activities related to this important issue. My comments are submitted recognizing the hard work that went into the report and related activities and are intended to constructively contribute in some way to the effort. I will focus only on aspects for which I believe I have some expertise and on key areas that I think need improvement.	No changes to the document were made in response to this comment.

Tracking Number	Date Received	Affiliation of Commenter	RULE	PLAN	Summary of Comment	Summary of TSSWCB Action or Explanation
59-04	07-21-2014	Dr. Jason West, Texas A&M University		X	With respect to the synthesis of existing research, in my view the plan does not represent a sufficiently rigorous assessment of the existing scientific literature and has a strong bias towards a small number of papers, many of which were published many decades ago. While it is of course not the case that research conducted some time ago is incorrect just because of its age, there is more recent work that provides a more nuanced treatment of relevant topics (plant water use, soil moisture dynamics, runoff, infiltration rates, brush removal methods, scaling approaches, and others) and this is largely absent from the report. In addition, and more importantly, there is not a sufficiently rigorous assessment of the existing literature for its relevance to a policy action like brush removal. Not all published papers are equally useful with respect to policy decision-making. This is particularly critical here since it seems that much of the existing literature would argue against the use of taxpayer dollars in the proposed manner (including many of the papers that were cited in the report). This is because the outcome in terms of ground or surface water resources is uncertain or likely to have no impact. This conclusion one might draw from the existing literature is not the conclusion apparently drawn in the proposed Plan.	No changes to the document were made in response to this comment.
59-05	07-21-2014	Dr. Jason West, Texas A&M University		X	I would therefore suggest that the Plan be formally reviewed by at least five external scientists who are actively working on research projects directly relevant to the proposed Plan. I understand that the Plan has an eminently qualified Science Advisory Committee, and make this suggestion as a way to enhance the scientific rigor of the relevant sections.	No changes to the document were made in response to this comment.
59-06	07-21-2014	Dr. Jason West, Texas A&M University		X	To be specific I think that Chapters 2, 3, and 4 in particular should be formally reviewed by external scientists prior to their use as the scientific basis for the implementation of the WSEP. The Plan attempts to synthesize work on ecohydrological systems across the state and so multiple researchers working in diverse areas would be needed to provide effective feedback on each. The reviews could perhaps be anonymous (although this is perhaps not ideal), but it would be important that all of the reviewers be actively conducting relevant research that is published in peer-reviewed literature.	No changes to the document were made in response to this comment.

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59-07	07-21-2014	Dr. Jason West, Texas A&M University		X	I also think it would also be important for Chapter 7 and Chapter 8 to receive rigorous, formal, scientific review since the structure of the feasibility studies is based on existing scientific tools and understanding as well although this review might be conducted by a separate group of external reviewers. It is not clear at all from the existing report that the feasibility studies will yield the needed information prior to implementation.	No changes to the document were made in response to this comment.
59-08	07-21-2014	Dr. Jason West, Texas A&M University		X	In addition, the status reviews described in Chapter 8 provide no information on how any assessment of impacts will be made other than maintenance of the brush control targets. This is a serious omission that should also be addressed in any revision. It would be most effective if these reviews then received a formal response with either specific changes, or a comment on why changes were not made, in an attempt to ensure that this feedback was used effectively.	No changes to the document were made in response to this comment.
59-09	07-21-2014	Dr. Jason West, Texas A&M University		X	I recognize that the planning process is on a timeline, but in my view the current report represents a pretty good initial “draft” summary of some of the existing literature, but one that is missing numerous key aspects and one that does not contain a sufficiently rigorous treatment of the current “state-of-the-science.” It therefore does not, in my view, provide a sufficient argument for the implementation of a statewide brush control program that has as its central objective enhancing the availability of either ground or surface water.	No changes to the document were made in response to this comment. See Preamble.
59-10	07-21-2014	Dr. Jason West, Texas A&M University		X	I wish the TSSWCB continued success as it tackles some of the most important challenges facing Texas as our soils and water resources face increasing challenges.	No changes to the document were made in response to this comment.
60-01	07-22-2014	S.K. Rosina Newton		X	Please accept my feedback on the proposed Plan. I am in complete agreement with comments submitted by my colleague Jason Dunsmore.	No changes to the document were made in response to this comment.
61-01	07-23-2014	Stephen J. Salmon, President, Riverside and Landowners Protection Coalition, Inc.		X	Riverside and Landowners Protection Coalition support the WSEP and urge that it continue. Total land-clearing is neither appropriate for wildlife, domestic livestock or water enhancement, but appropriate brush or woody plant removal is. We, therefore, support the continuation of the WSEP.	No changes to the document were made in response to this comment.
61-02	07-23-2014	Stephen J. Salmon, President, Riverside and Landowners Protection Coalition, Inc.		X	Probably long forgotten or not even known by younger generations, Rocky Creek near San Angelo started to flow again after brush and tree removal by a landowner. Nearby springs started flowing again. All of this took place in the drought of the 1950s.	The document was revised in response to this comment.

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61-03	07-23-2014	Stephen J. Salmon, President, Riverside and Landowners Protection Coalition, Inc.		X	Some projects in the original BCP were done as pilot projects and were chosen due to a very small number of landowners to deal with. These landowners have a very small watershed that has not received normal or significant rainfall since it was started. There is a lot of finger pointing at that project as an example of failure. NO, it has not failed.	No changes to the document were made in response to this comment.
61-04	07-23-2014	Stephen J. Salmon, President, Riverside and Landowners Protection Coalition, Inc.		X	TAMU has a well-documented study of the effects of canopy cover on rainfall that shows most of the rain does not ever reach the ground. This research alone should be indicative of the need for brush removal.	No changes to the document were made in response to this comment.
61-05	07-23-2014	Stephen J. Salmon, President, Riverside and Landowners Protection Coalition, Inc.		X	Only in recent years has there been a connection made between surface and groundwater. That connection continues to be explored, and I am sure it is more apparent in some regions in Texas than others.	No changes to the document were made in response to this comment.
62-01	07-23-2014	Phillip Munden, Chairman, Bosque SWCD #555		X	The Bosque SWCD #555 is proud to support the WSEP administered by the TSSWCB. As members of the association, we have partnered with many producers to clear thousands of acres of land of brush and specifically Cedar.	No changes to the document were made in response to this comment.
62-02	07-23-2014	Phillip Munden, Chairman, Bosque SWCD #555		X	Research has proven that when specific brush species are removed in areas with certain soil types and topography, water yield increases during rainfall events.	No changes to the document were made in response to this comment.
62-03	07-23-2014	Phillip Munden, Chairman, Bosque SWCD #555		X	Technology is used to develop specific plans for brush removal that continue to provide wildlife habitat and increased water yields.	No changes to the document were made in response to this comment.
62-04	07-23-2014	Phillip Munden, Chairman, Bosque SWCD #555		X	The cost-share benefit provided through this program allows producers the opportunity to participate in the program that might not otherwise have the resources to remove the brush.	No changes to the document were made in response to this comment.
62-05	07-23-2014	Phillip Munden, Chairman, Bosque SWCD #555		X	With Texas in the midst of one of the worst droughts in history, we need to look at all the options available to make the most of our water resources, including water enhancement through brush control. Increased water yields into streams, rivers, and reservoirs are a benefit to all Texans.	No changes to the document were made in response to this comment.
63-01	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association		X	First, let me say that the TSGRA is a strong believer in brush control measures as a viable and productive method of surface and ground water enhancement.	No changes to the document were made in response to this comment.

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63-02	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association		X	I would ask that the TSSWCB keep in mind that since the North Concho River watershed project was initiated, we have continued to be well below average annual rainfall. With this in mind, it is really difficult to evaluate the long-range benefit of such projects. However, there was a prior pilot project on Spring Creek in the San Angelo area that showed us, beyond the shadow of a doubt, the benefit of controlling mesquite and juniper.	No changes to the document were made in response to this comment.
63-03	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association		X	Over the years, I have observed NRCS, TSWCB and Texas A&M Extension demonstration projects that clearly showed what a juniper and mesquite canopy does to inhibit rainfall from actually reaching the soil. We also well know that beneficial grasses and ground cover definitely hold/retain water where it falls, thus providing soil and subsoil percolation. Needless to say, this definitely provides a source for aquifer recharge.	No changes to the document were made in response to this comment.
63-04	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association		X	Removal, or partial control, of noxious growth such as juniper or mesquite enhances growth of grasses and turf growth. A good turf, or growth of grasses and quality vegetation provides a much cleaner runoff for our streams and lakes, thus enhancing not only water quantity but also is most helpful in improving water quality.	No changes to the document were made in response to this comment.
63-05	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association		X	We feel that sculpturing is a far more desirable method of brush control than total pasture eradication. This approach provides adequate cover for wildlife, which we all realize is a most important part of our overall agricultural operations. We state this in opposition to the theory that is held by some that a brush "choked" pasture is more desirable for wildlife production.	No changes to the document were made in response to this comment.
63-06	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association	X		Thus, in closing, our general position is in support of your proposed revision of rules for the WSEP.	No changes to the document were made in response to this comment.
63-07	07-23-2014	Chris Jamison, President, Texas Sheep and Goat Raisers' Association	X	X	However, it is my candid proposal that further extension be provided. I feel that most of the affected associations and organizations are in the process of conducting their annual meetings, thus bringing the membership together to deal with such issues as your proposed rule changes. An additional 30-day extension would give me, as well as other association leaders, an opportunity to gather the thoughts of our membership.	No changes to the document were made in response to this comment.

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