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Economic Impacts of Salinity Control Measures for the Upper Pecos River Basin of Texas

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By
William Thompson
Texas AgriLife Research and Extension Center San Angelo
Texas AgriLife Extension Service

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Executive Summary

This report presents the results for Subtask 1.7 of the Pecos River Basin Assessment project sponsored by the U.S. Environmental Protection Agency (EPA) and the Texas State Soil and Water Conservation Board (TSSWCB). The original objective of Subtask 1.7 was to measure the economic impact of Tamarix spp. (saltcedar) control along the Texas portion of the Pecos River. As work progressed on other hydrologic studies associated with this project, the scope of the project shifted to analyze the expected economic impacts of implementing potential salinity control measures on the Pecos River above Red Bluff Reservoir to decrease salinity levels in water used for irrigation in Texas. Scenarios evaluated quantified the economic impact of improving water quality used by Texas irrigators to the level of water utilized by the Carlsbad Irrigation District in southern New Mexico. The purpose for this evaluation was to see if the overall economic impact of producing less salt tolerant, more profitable crops might be significant enough to encourage producers to convert current cropping practices to more profitable practices not currently useable due to elevated irrigation water salinity levels.

Between 1970-2005, irrigation storage and delivery data from the Red Bluff Water Power Control District (RBWPCD) were analyzed and water delivery from the year 2005 was used as a representative level of available irrigation water. Estimates of current cropping patterns for the irrigated lands within the seven sub-districts of the RBWPCD were established. Data were collected and reviewed for the Carlsbad Irrigation District of New Mexico, just up stream from Red Bluff Reservoir, to establish two estimated alternative cropping patterns under a reduced salinity environment. The differences in the value of farm production between the baseline scenario and the two alternative cropping patterns were entered into the Impact Analysis for Planning (IMPLAN) input-output model of the six county upper Pecos River Basin to quantify the general economic impact to the local economy as a result of changes in current cropping practices.

As compared to the typical cropping practices, *Alternative 1* reduces the more salt tolerant cotton acreage and moderately tolerant wheat acreage while increasing the acreage of moderately salt sensitive alfalfa. The direct output effect for this alternative cropping pattern was $1,446,206; an increase of 120 percent over the current typical cropping system. The total economic impact to the local economy was $2,807,166 with a net creation of 1.17 full time employee (FTE) jobs. This scenario did not incorporate the impacts to local cotton gins and as a result may be a less desirable option.

Alternative 2 maintains cotton acreage, reduces wheat acres, and increases alfalfa acres as compared to typical practices. Compared to *Alternative 1*, this scenario models one-third of the alfalfa acreage, 5.5 times more acres cotton and equal amounts of wheat. The direct output effect for this alternative cropping pattern was $815,378; an increase of 130 percent over the current typical cropping system. The total economic impact was $1,588,795, and will generate a net increase of 7.8 FTE jobs.

The combined effective delivery losses of the Pecos River channel and the sub-district delivery infrastructure have averaged 55.5 percent since 1970. Uncertainty stemming from weather patterns, annual irrigation water availability, and the delivery losses of the current system complicate planning and deter investments by both farmers and irrigation districts making a large-scale conversion from current cropping practices to potentially more profitable practices less likely. In order to increase the likelihood of cropping changes and promote future irrigated agriculture in the basin, a new study of the infrastructure improvements for the RBWPCD and the 7 sub-districts is needed; this was last done in 1991.

This study did not measure the impact of increasing available water supplies because it is outside the revised scope of the project and is furthermore an unlikely scenario given the region's climate. Tremendous increases in grain prices, fuel, and fertilizer costs in recent months can potentially alter economic impacts predicted by this study; these dramatic changes have likely changed demand and production functions of several industries. An updated analysis is needed to better quantify potential economic impacts under the current economic situation.

The primary focus of this analysis has been on irrigated farm production; however, the initial intent was to evaluate the economic impacts of saltcedar control in the riparian corridor in general. A large majority of lands in the riparian corridor and watershed are classified as rangelands; which can have a significant impact on the watershed's economy. Results of a survey of landowners/managers along the Pecos River can be found in appendix 2. This survey was conducted to quantify economic impacts realized by landowners along the river as a result of saltcedar treatment along the river. Generally speaking, these landowners/operators have had little economic benefit or value from the treatment of saltcedar along the Pecos River.

Study Area

The Pecos River is the largest U.S. tributary into the Rio Grande and spans 418 river miles in Texas alone. The Pecos River Basin is bounded by the Rio Grande to the south and west (Amistad International Reservoir), the New Mexico portion of the basin to the north and the Colorado River and Edwards Plateau to the east (figure 1).

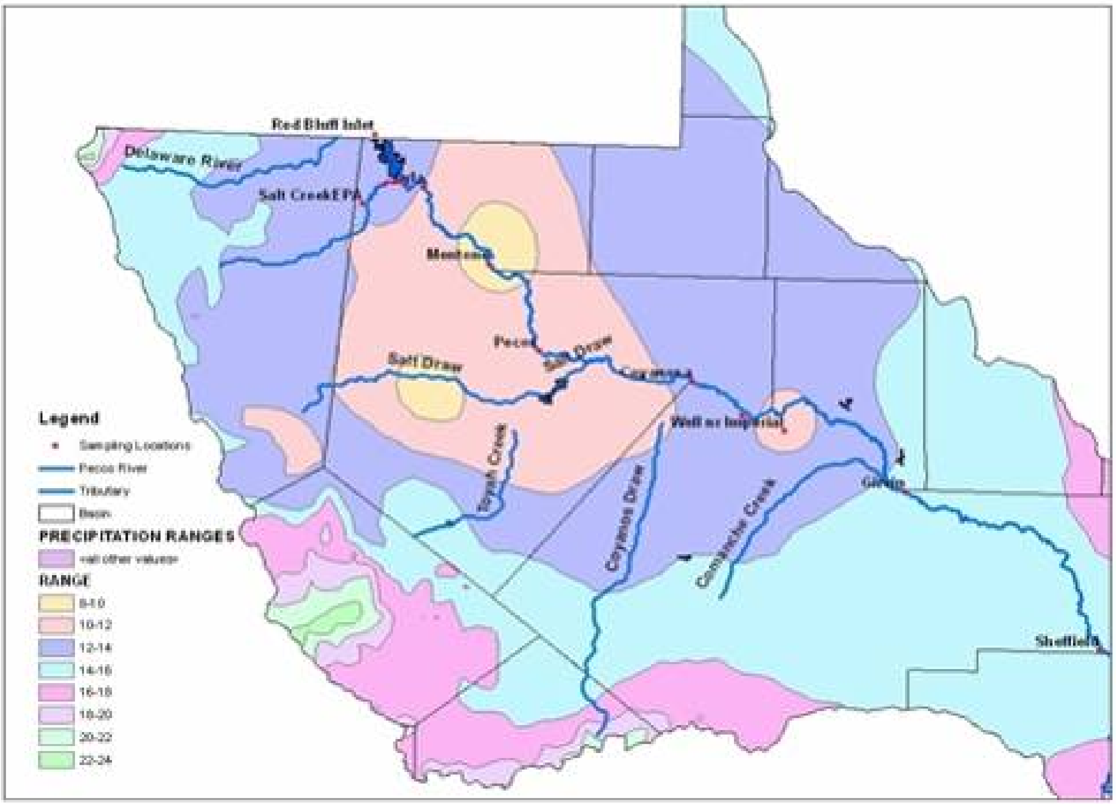

Figure 1. The Texas portion of the Pecos River Basin

Much of the Pecos River drainage area is categorized as Chihuahuan Desert and receives an annual rainfall that varies by location between 9.3 and 12.4 inches per year, with most of that (66-84 percent) coming in late spring to late summer (April-September). Pan evaporation and evapotranspiration greatly exceed precipitation in all but the wettest years. Portions of the Texas Pecos River basin are characterized by silty clay loam and clay loam soils (USDA, ASCS, NRCS) which are well suited to crop production under irrigation. The growing season across much of the basin ranges from 215 to 230 days and is also well suited to crop production. These conditions have enticed speculators, investors, and farmers to pursue development of irrigation projects since the mid-1800s. Most of the surface water distribution systems in use now are a result of the projects developed between 1884 and 1914 and are in dire need of system upgrades. Many of these systems were initiated by speculators and developers hoping to entice settlers with the prospects of growing irrigated crops. Unfortunately, many of these earlier attempts to irrigate the basin ceased to exist because of drought or occasional floods; droughts reduced the flow of the Pecos River to levels that made diversion from the river impractical and floods simply washed away the investment of the developers and speculators. Drought, or lack of available water from Red Bluff for irrigation use, continues to be a concern for irrigators in the watershed and has led to decreased reliance on surface waters for irrigation.

Seven irrigation districts operate within the upper portion of the Pecos River Basin between Red Bluff Dam and Girvin, Texas (figure 2). Downstream from Girvin to Amistad International Reservoir there is no cultivated land irrigated out of the river. For this analysis the upper Pecos River basin is defined as the river between Red Bluff Dam and Girvin and adjacent watershed areas encompassing portions of Loving, Winkler, Ward, Reeves, Crane, and Pecos counties. Virtually all cultivated land within the basin is under irrigation and produces traditional crops such as cotton; small grains; sorghum forage; and specialty crops including cantaloupes, melons, onions, peppers, and other vegetables. Pecan orchards can also be found throughout the Pecos River Basin. The largest percentage of land in the watershed is considered rangeland, and oil and natural gas production and oil field services are the major industries within the study area.

The construction of Red Bluff dam just below the Texas-New Mexico state line was initially thought to be able to harness the Pecos River and the storage capacity of the lake believed to buffer the effects of floods and droughts. This has partially been the case, but lengthy drought conditions and increased demands and water losses in the reservoir and the delivery system all contribute to the reservoir’s inability to completely shield agricultural interests from the effects of nature. Construction of the dam was completed and water storage began at Red Bluff Reservoir in 1936. Since then, water is released from the reservoir upon request and delivered to the respective sub-districts via the Pecos River channel to designated diversion points downstream.

Several sources have identified acreage that could be irrigated in each of the districts. The 1965 Bureau of Reclamation study estimated 140,000 acres were suitable for irrigation, the Water Right Adjudication for Red Bluff Reservoir lists 93,013 acres within the seven sub-districts, and a 1979 Texas Department of Water Resources report identified 137,324 arable acres. Table 1 summarizes the 1965 Bureau of Reclamation estimation of acreage within each sub-district that is suitable for irrigation, as well as land that was designated for inclusion in primary and secondary service areas, and the percentage of Red Bluff water allocations permitted by the master contract with the Texas Department of Water Resources.

Table 1. Acreage and water allocations of Red Bluff constituent sub-districts

Water Improvement Districts (WID)	Selected as physically suited for irrigation[1]	Designated Service Areas[2]			Water allocations per Master Contract (percent)
		Primary	Secondary	Total	
Loving Co. No. 1	1,560	682	403	1,085	3.1
Reeves Co. No. 2	2,040	1,936	1,144	3,080	8.8
Ward Co. No. 3	2,490	1,826	1,079	2,905	8.3
Ward Co. No. 1	8,900	5,214	3,081	8,295	23.7
Ward Co. No. 2	12,780	6,050	3,575	9,625	15.3
Pecos Co. No. 2	7,920	3,366	1,989	5,355	13.3
Pecos Co. No. 3	7,060	2,926	1,729	4,655	27.5
Totals	42,750	22,000	13,000	35,000	100.0

[1] Selected by Bureau of Reclamation, 1965
[2] Designated by the Districts, 1965.

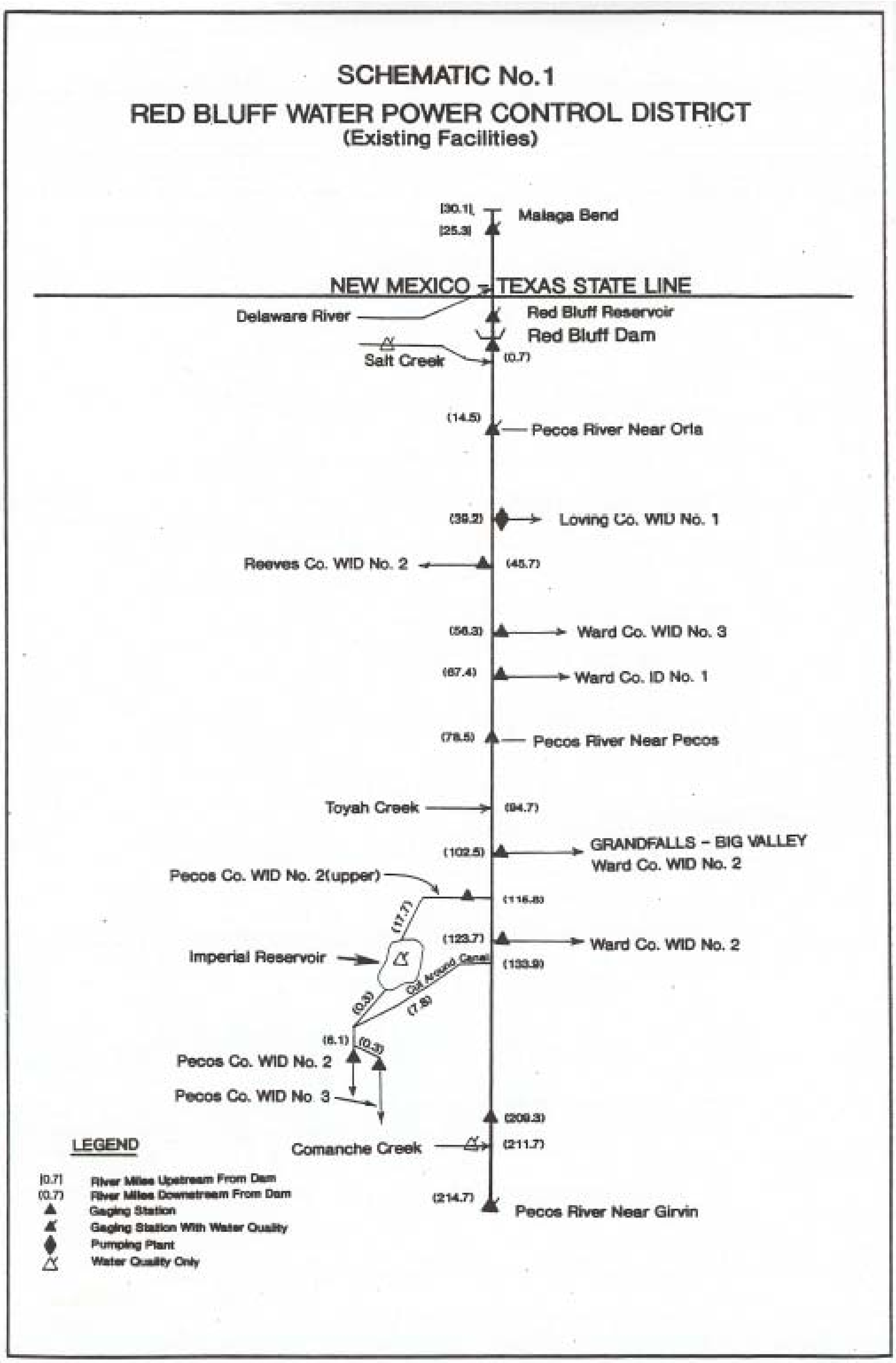

Figure 2. Red Bluff Water Power Control District existing facilities

Riparian areas near the Pecos River in Texas, like many riparian areas of the western U.S., have seen a dramatic invasion of Tamarix spp. (saltcedar). Saltcedar was originally introduced into the Pecos River Basin to stabilize stream banks from the effects of erosion. Several saltcedar characteristics have allowed the trees to develop into dense monoculture stands impenetrable to native riparian species, wildlife, or livestock. Studies have indicated that saltcedar has the ability to consume large amounts of water and increase salt loadings of the river by drawing salts from below ground and depositing them on the surface in leaf litter (Belzer and Hart, Hart et al. 2005). To decrease this infestation, a major saltcedar treatment effort was initiated in 2001 and has treated more than 12,000 acres along the Pecos River and its tributaries to date.

The *Pecos River Compact*, signed by Texas and New Mexico, approved by congress, and signed by the President on December 3, 1948, outlines the equitable division and apportionment of the use of the Pecos River in Texas and New Mexico. The compact does not address the quality of water delivered from New Mexico to Texas. In 1974, the state of Texas filed suit against the state of New Mexico alleging that New Mexico had not complied with the compact in maintaining deliveries of water to Texas between 1950 and 1983. In 1987, the Supreme Court ruled in favor of Texas, declaring that New Mexico deprived Texas of 340,100 acre feet of water during this time period. As a result in 1989, Texas was awarded a cash settlement of $14 million for damages.

Salinity levels of the Pecos River increase markedly near the Malaga Bend area of New Mexico due to a hydrological connection to a highly saline aquifer (figure 3). The discharge into the river is largely responsible for poor water quality at Red Bluff Reservoir and below. Between 1963 and 1976, the U.S. Geologic Survey (USGS) in cooperation with the Pecos River Compact Commission and RBWPCD operated the Malaga Bend Salinity Alleviation Project. This operation pumped 645 acre-feet of groundwater from underlying the aquifer annually to remove the head or water pressure forcing salty water into the river. The water was pumped into surrounding playa lakes to allow the water to evaporate and the salt to be commercially harvested and marketed. A series of technical issues have prevented this project from achieving long term success. Although this effort was not successful over the long-term, when the system was functioning properly a 25 percent decrease in downstream salinity levels were achieved. It is thought that if these technical difficulties can be corrected the market value of the harvested salt may make costs of future salinity alleviation efforts neutral to the RBWPCD, the seven sub-districts, and the individual irrigators while simultaneously improving the quality of water downstream of Red Bluff.

Literature Review

Academic study of the Pecos River Basin can be separated largely into two categories: an analysis of the physical quantity and quality of the river, associated stream inflows, and available irrigation water; and the economic valuation of irrigation water and farm survivability. Regardless of the type of study, it is generally agreed that the Pecos River watershed presents a myriad of problems that all resource managers must address. The quote below sums up this sentiment.

> For it size, the basin of the Pecos River probably presents a greater aggregation of problems associated with land and water use than any other irrigated basin in the western United States. These involve both quantity and quality of water supplies, the problem of salinity being particularly acute, erosion and silting reservoirs and channels, damage from floods, and interstate controversy over the use of the waters. There is an abundance of good land so that the limit of development is the availability of water of satisfactory quality. The use of the water of the river has been fully appropriated.[3]

Flow/Delivery Studies

The Pecos River as an irrigation delivery system has been scrutinized for some time. The first low flow study was conducted in 1918 and more recent and significant work by Grozier et al. (1966, 1968) found that 57 percent of the water released from Red Bluff Reservoir was lost to shallow water aquifer recharge, evaporation, or transpiration. This finding closely coincided with our analysis of Red Bluff release and delivery records that indicated a 55 percent loss between the dam and irrigator. In addition, a significant degradation of water quality (chlorides) was also noted in this study. Grozier's studies analyzed the Pecos River in segments, or reaches, finding that some portions of the river lost streamflow while other segments gained streamflow. A 1991 Bureau of Reclamation study identified and evaluated various plans for rehabilitating or improving the delivery efficiency of the Pecos River and points out several issues: large fluctuations in the supply of water in Red Bluff reservoir will continue, initial water quality at Red Bluff is a key issue, and evaporation and phreatophyte losses are insignificant when compared to the Pecos river losses.

Studies conducted by Miyamoto et al. have focused on flow balances of the Pecos River and total salt loading occurring at the watershed outlet Amistad International Reservoir. Miyamoto et al. (2005) analyzed streamflow and salinity data at 11 gauging stations on the Pecos River from the head-waters in New Mexico down to Girvin, Texas. The analysis revealed that the majority of salt loading in the Pecos River is occurring in three reaches of the river, all of which are in New Mexico. The salt load is reduced between Red Bluff and Pecos due to diversion for irrigation and high seepage losses, but increases again between Coyanosa and Girvin, Texas. Figure 3 presents historical streamflow and salinity data from the 11 gauging stations from Santa Rosa nearer the headwaters of the Pecos River down to Girvin, Texas, approximately 215 river miles below Red Bluff

[3] Federal Natural Resources Planning Board, The Pecos River-Joint Investigation in the Pecos River Basin-Summary, Analyses, and Findings, Regional Planning, Part X, June 1942.

Reservoir. These salinity levels have created several agronomic issues for producers and caused thousands of formerly irrigated acres to be idled. Most crop rotations and irrigation practices have been altered to accommodate increasing salinity.

Miyamoto et al. (2007) identifies separate salinity control measures that could potentially be used to mitigate the salt loading in the Pecos River and ultimately Amistad International Reservoir; however, feasibility studies are needed to optimize the location and design of these practices prior to implementation. Measures include increasing inflow, reducing brine intrusion, and modifications to current water management practices. The results of increasing inflows into the Pecos River are dependent on the uses of river water, weather patterns, and the salinity levels of additional inflows; it is not likely that inflows to the river will drastically increase. It is possible that increasing the inflows will reduce the salinity within the river, but increasing inflows could also increase total salt load. The reduction of brine intrusion could reduce the salinity of current inflows, but could also decrease the volume of flow in the river; which seems to be a more feasible management option than expecting inflows to increase. Modification of water management practices involve holding irrigation allotments upstream in deeper

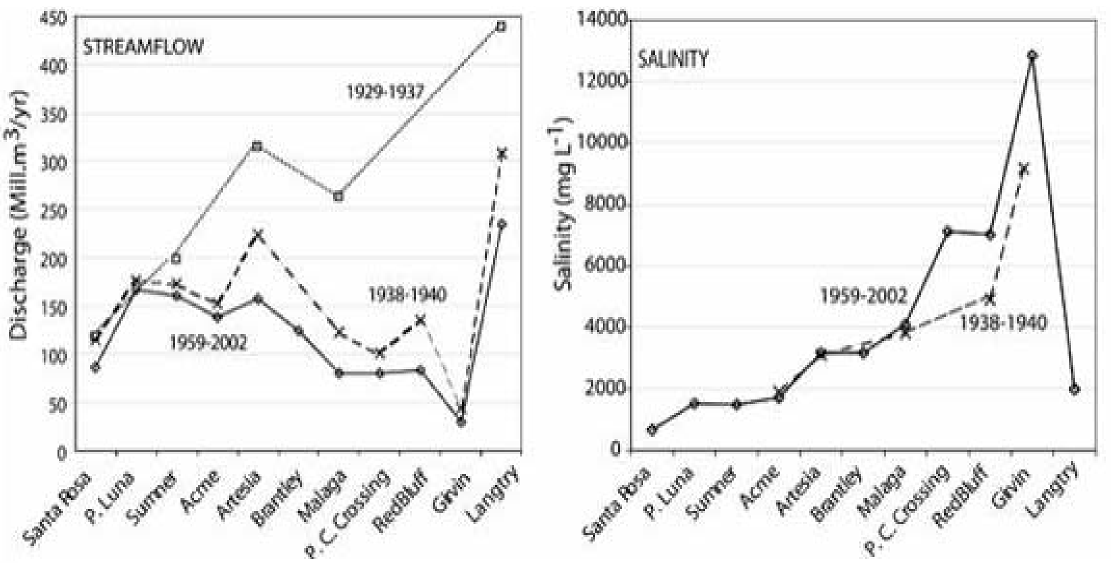

Figure 3. Flow of the Pecos River at selected gauging stations; dotted line 1929-1937, dashed line 1938-1940, solid line 1959-2002. Salinity data prior to 1937 are not available. (Miyamoto et al., (2007))

reservoirs longer and making irrigation releases to downstream reservoirs closer to the irrigation season. The intent of these strategies is to reduce the overall surface to depth ratio of Red Bluff Reservoir in an attempt to reduce evaporation losses.

Economic Analysis of Pecos River Water, Irrigation, and Invasive Shrubs

Over time there have been numerous economic studies conducted analyzing the value of Pecos River flows. In 1970, Hughes investigated increasing Pecos basin water supplies through a reduction of evaporation and evapotranspiration. His analysis found that the removal of timber at the head waters of the Pecos River was not feasible due to costs.

Furthermore, construction of snow fences in the headwater regions were unlikely to yield enough water to be a realistic solution with present water values.

Lansford et al. (1970) established criteria for the economic classification of irrigated cropland in the Pecos River Basin. Quality and quantity of irrigation water affects income expectations resulting in variations in the economic classification of land. Increased salinity causes a shift to salt tolerant crops or moderately tolerant crops combined with heavy, frequent irrigation (leaching); ultimately causing lowered income potential and/or increased costs. This effort also determined that better land managers generated superior returns and were able to acquire access to better farm land over time while poorer managers were relegated to the less productive land. Specific water use efficiencies and consumptive irrigation requirements for cotton, alfalfa, fall and spring planted small grains, grain sorghum, and corn and sorghum silage for the Pecos River Basin were also measured (Lansford et al. 1969). While flow and delivery studies focus on the scarcity of water in the Pecos River Basin, d'Arge distinguishes between physical and economic shortages of water (1970). Physical water shortages refer to the availability of water resources to meet all water requirements. Economic water shortages refer to shortages that seriously impede economic development and/or exhibit relatively higher costs or prices compared with water in other geographic areas. d'Arge also notes that the import value of water in the Pecos River Basin is quite low since water could be transferred in small amounts from irrigated agriculture without seriously affecting this sector.

Several investigators contemplated simulating individual Pecos River Basin farm responses to various economic stimuli. Ellis et al. (1990) employed two simulation models to develop yield distributions and calculate probabilities of firm survival over multi-year periods. This study focused on groundwater irrigation, but two results are important to this current analysis. Restricted water availability resulted in non-optimal irrigation schemes being employed by farmers, and even at optimal irrigation rates, declining net worth was predicted in all but the most optimistic scenarios. Similarly, Condra et al. (1979) studied the feasibility of groundwater irrigated crop production in the Pecos River Basin and determined that cotton would likely remain the primary crop under most scenarios. Predictions deduced that under the present farm policy (at the time), farm survival was estimated between 20 and 30 percent (Condra et al. 1979).

Control or eradication of invasive saltcedar is often viewed as necessary to return a water body or entire watershed back to its historical state. Sheng et al. (2007) have specifically studied the Pecos River's response to saltcedar control, as they monitor gains and losses within specific river reaches. Research suggests that a reduction in evapotranspiration loss to saltcedar may contribute to more recharge into shallow aquifers rather than the increase of stream flow in a losing reach of the river.

Methods

Data were collected from the RBWPCD on estimated water in storage on March 1 of each year, annual irrigation allotments authorized by the RBWPCD, actual water releases, and delivery quantities to each of the sub-districts. Table 2 summarizes these data back to 1970. In four years (11 percent), no irrigation allotment was made, nor were releases of irrigation water made. Effective delivery loss of the Pecos River channel is defined as the difference between water released and water deliveries billed to the sub-districts; delivery loss is calculated on this table. The quantity delivered to each district is gauged at the respective sub-district diversion and further delivery losses become the responsibility of the sub-district. Thirty-six percent (13 years in 36) of these losses exceed 50 percent of the water released from the dam.

Table 2. Red Bluff Water Power Control District surface water management data

Year	Storage March 1	Total Annual Allotment	Actual releases	Delivered (billed) to Sub-districts	Effective Delivery Loss	Delivered (billed) to Producers	Sub-district delivery loss	Total Loss	Total Loss
	Ac-ft	Ac-ft	Ac-Ft	Ac-ft	%	Ac-ft	%	Ac-ft	%
2005	123,270	25,000	62,290	17,331	72.2	13,287	23.3	49,003	78.7
2004	57,300	25,000	42,089	18,730	55.5	11,148	40.5	30,941	73.5
2003	59,819	0	0	0	N/A	0	N/A	0	N/A
2002	41,000	0	0	0	N/A	0	N/A	0	N/A
2001	72,000	25,000	53,711	23,760	55.8	20,018	15.7	33,693	62.7
2000	89,600	35,000	56,186	32,870	41.5	23,902	27.3	32,284	57.5
1999	71,300	25,000	33,064	23,165	29.9	17,803	23.1	15,261	46.2
1998	98,500	40,000	59,594	35,000	41.3	24,959	28.7	34,635	58.1
1997	80,000	30,000	53,025	28,170	46.9	26,042	7.6	26,983	50.9
1996	77,000	30,000	44,556	29,777	33.2	22,936	23.0	21,620	48.5
1995	88,300	33,000	43,038	33,000	23.3	30,431	7.8	12,607	29.3
1994	109,100	58,834	51,315	44,000	14.3	34,252	22.2	17,063	33.3
1993	162,100	95,000	77,997	49,099	37.1	38,007	22.6	39,990	51.3
1992	132,100	60,000	38,479	30,550	20.6	19,046	37.7	19,433	50.5
1991	77,200	25,000	27,268	25,000	8.4	14,259	43.0	13,027	47.7
1990	101,600	40,000	45,333	40,000	11.8	25,595	36	19,743	43.5
1989	185,800	70,000	84,673	68,971	18.5	54,285	21.3	30,388	35.9
1988	226,700	10,0000	53,099	35,862	32.5	26,185	27.0	26,914	50.7
1987	270,000	70,000	107,468	23,460	78.2	15,056	35.8	92,412	86.0
1986	78,200	20,000	33,588	10,710	68.1	7,399	30.9	26,189	78.0
1985	101,300	20,000	33,645	13,013	61.3	11,118	14.6	22,527	67.0
1984	46,900	0	0	0	N/A	0	N/A	0	N/A
1983	56,600	10,000	19,100	6,260	67.2	5,374	14.2	13,726	71.9
1982	61,000	10,000	22,077	7,840	64.5	4,806	38.7	17,271	78.2
1981	73,700	20,000	32,800	13,920	57.6	11,950	14.2	20,850	63.6
1980	85,000	25,000	34,500	25,000	27.5	22,255	11.0	12,245	35.5
1979	109,600	45,000	48,000	27,810	42.1	24,349	12.3	23,606	49.2
1978	25,000	0	0	0	N/A	0	N/A	0	N/A
1977	70,700	20,000	39,600	17,035	57.0	19,617	-15.2	19,983	50.5
1976	109,300	40,000	41,600	40,000	3.8	27,979	30.1	13,621	32.7
1975	176,800	50,000	61,108	36,762	39.8	31,026	15.6	30,082	49.2
1974	57,300	15,000	23,830	11,790	50.5	9,243	21.6	14,587	61.2
1973	53,500	25,000	43,301	17,995	58.4	19,390	8.9	26,911	62.1
1972	45,600	10,000	24,700	7,845	68.2	5,054	35.6	19,646	79.5
1971	64,900	20,000	33,962	18,720	44.9	19,341	-3.3	14,621	43.1
1970	103,000	40,000	53,747	34,136	36.5	27,334	19.9	26,413	49.1
Avg.	95,586	32,134	41,077	23,544	42.8	20,640	21.6	25,571	55.5

Data was collected from each of the seven sub-districts on the quantities of irrigation water delivered to producers. Effective delivery loss by the respective sub-districts was calculated in the same manner as the loss calculations for the Pecos River. Only five years were recorded with sub-district deliveries less than an additional loss of 10 percent (average loss is 21.6 percent). This includes 1977 and 1971 when more water was delivered to producers than to sub-districts. This could be explained as a large precipitation event providing runoff to the delivery system.

Total delivery losses calculated as the difference between Red Bluff releases and billed deliveries to irrigators ranged from a high of 86 percent (1987) to a low of 29.3 percent (1995). Average losses for the complete delivery system averaged 55.5 percent.

Summarized data from the Texas Water Development Board (2001) for Reeves, Pecos, Loving, and Ward Counties is available in table 3. Irrigation application in these counties averaged 3.06 ac-ft per irrigated acre. This allows for an estimated 4,328 acres to be irrigated in 2005 with 13,287 ac-ft delivered to irrigators by the seven sub-districts.

Table 3. Summary of Pecos River Basin surface water irrigation (Texas Water Development Board data for 1958-2000)

	Reeves		Pecos		Loving		Ward		Texas Pecos Basin		
Year	**Acres**	**Ac-ft**	**Acres**	**Ac-ft**	**Acres**	**Ac-ft**	**Acres**	**Ac-ft**	**Acres**	**Ac-ft**	**Acre Ft /Ac**
2000	3,320	10,811	1,199	1,824	140	358	3,620	10,597	8,279	23,590	2.8
1994	80	300	253	253	140	583	2,475	10,781	2,948	11,917	4.04
1989	733	3,527	1,697	7,530	20	42	3,080	13,705	5,530	24,804	4.48
1984	0	0	0	0	0	0	0	0	0	0	0
1979	245	613	0	0	30	40	100	333	375	986	2.63
1974	80	317	0	0	17	51	127	317	224	685	3.05
1969	100	333	0	0	17	68	242	627	359	1,028	2.86
1964	7,200	11,200	0	0	100	273	0	0	7,300	11,473	1.57
1958	11,000	33,100	0	0	200	700	0	0	11,200	34,100	3.04
Avg.	2,529	6,722	1,050	3,202	74	235	1,072	4,040	4,024	12,065	3.06

The estimated crop mix in the Pecos River Basin reflects cotton as the primary crop in the region with 58.5 percent of the irrigated acreage. Wheat accounts for an additional 30.5 percent while alfalfa (7.6 percent) and sorghum forage (3.4 percent) account for the remaining acreage (Medeiros, NASS). While significant wheat acres are planted each year, only 33 percent of the planted acres appear to be harvested for grain each year. It is suspected that salinity levels reduce wheat’s ability to yield grain above economic thresholds for harvesting; ultimately resulting in this forage being grazed.

The impact of salinity control measures similar to those proposed by Miyamoto et al. 2007 will be assessed by estimating the change in the value of farm production resulting from alterations in the crop rotation/mix as irrigators react to lower salinity levels. The mix of crops used for this analysis will be based partly on the complexion of irrigated agriculture between Artesia and Malaga Bend and implies that the proposed salinity control measures can maintain the water quality between Red Bluff and Girvin at salinity levels of the water being measured upstream of Malaga, New Mexico (figure 3).

The Carlsbad Irrigation District (CID) operates and maintains three dams (Brantley, Sumner, and Avalon) on the Pecos River north of the city of Carlsbad, New Mexico and utilizes 37 miles of canal and 151 miles of pipe to irrigate up to 25,055 acres. Data from the CID was used to provide crop mix data and water usage (table 4) that was applied in the Texas portion of the Pecos River Basin in this analysis; assuming salinity levels are reduced. The perennial nature of alfalfa is reflected in the multi-year lag in the reduction of alfalfa acres following dry years when less than full irrigation allotment is made.

Table 4. Crop mix and irrigation water allotment for the Carlsbad Irrigation District

	2003	**2005**	**2005**	**2006**
Crop	**Irrigated Crop Acres[4]**			
Oats	269	294	210	200
Alfalfa	11,940	12,185	8,210	9,803
Irrigated Pasture	642	755	510	560
Cotton	1,248	1,465	7,126	4,793
Grain Sorghum	383	450	250	350
Wheat	27	80	200	250
Corn/sorghum Silage	592	575	658	700
Vegetables/Melons	4	25.5	34	42
Other	0	350	380	500
Total Acres	15,107	16,180	17,578	17,198
	Irrigation Water Used			
% of Full Allotment	31.1%	63.6%	100%	81%
Ac-Ft per Acre	1.53	2.14	3.06	2,85

Yield potential is difficult to estimate due to varying quantities of available irrigation water, variation in rainfall patterns, and incomplete data sets. Table 5 summarizes estimated historical yields in Pecos, Reeves, and Ward Counties as reported by Texas AgriLife Extension Service county personnel. Crop specific acreage and yield data was not available for Loving and Winkler through either Texas AgriLife Extension Service or the National Agricultural Statistics Service.

Table 5. Estimated acreage and yields for cotton (lbs/acre) and alfalfa (tons/acre) for selected Pecos River Basin counties

Alfalfa														
	2000		2001		2002		2003		2004		2005		2006	
County	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield
Pecos			832	10.5	832	10.2	4,438	12.0	4,340	3.25	5,635	3.25	4,500	11.46
Reeves			4,600	3.0			5,000	3.0	503	7.5	1,841	7.5	2,700	2.07
Ward			350	4.1	100	3.25	100	4.9	100	5.0	140	5.0	165	5.0
Weighted Average				4.15		9.45		7.2		3.72		4.31		7.87

Cotton														
	2000		2001		2002		2003		2004		2005		2006	
County	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield	Acres	Yield
Pecos	6,700	996	6,063	1,100	4,200	1,050	6,662	1,425	5,750	1,043	6,711	915	2,500	1,250
Reeves	4,900	568	8,400	1,000	1,958	1,296	8,000	1,000	4,044	750	3,300	1,481	3,700	768
Ward			800	450					200	150	423	150	700	125
Weighted Average		812		1,011		1,128		1,193		907		1,063		877

Does not include irrigated Pecan orchards or acres irrigated but not harvested.

Results

The estimated delivered irrigation water and acreage allocation for 2005 were used as the base scenario for 2006 irrigated crop production in the Pecos River Basin. Two alternative scenarios where acreage is reallocated to crops that are perhaps less salt tolerant (Ayers and Westcot 1985), but provide for greater potential returns to land, labor, and management are presented in table 6. *Alternative 1* reduces more salt tolerant cotton and moderately tolerant wheat acres while increasing moderately salt sensitive alfalfa acreage. *Alternative 2* maintains cotton acreage while reducing wheat acres and increasing alfalfa acres.

Table 6. Allocation of crop acres, commodity prices, and estimated yields for base scenario and alternatives

	Base Scenario	Alternative 1	Alternative 2	Commodity Prices	Estimated Yields
Crop	**Acres**			**$/unit**	**Unit/Ac**
Alfalfa	329	3,246	1,122	$150	6.1 tons
Cotton	2,532	488	2,612	Lint $0.52/lb Seed $0.05/lb	1,030 lbs 1,648 lbs
Grain Sorghum	0	185	185	$5.00/cwt	56 cwt
Oat hay	0	51	51	$120/ton	4.5 ton
Sorghum Forage	147	169	169	$110/ton	6 tons
Wheat – Pasture	884	0		$0.35/ lb-g	64 lbs
Wheat - Grain	436	189	189	$4.55/bu	30 bu
Total Acres	**4,328**	**4,328**	**4,328**		

cwt = hundred weight; bu = bushels

Further analysis was conducted using the IMPLAN input-output model and information from the IMPLAN data set for Texas counties in 2006. Input-output analysis creates a picture of a regional economy describing flows to and from industries and institutions, and can be used to predict changes in overall economic activity as a result of specified changes in the local economy. In this analysis the change in the local economy is the reduction of salinity levels of the Pecos River irrigation water which allows for production of more valuable, less salt tolerant crops.

An economic model of the study area was built with the IMPLAN software. See appendix A for a summary of industry output, employment, and a detailed breakdown of total value added for the six county upper Pecos River Basin study area. The base model was amended with net changes in the value of farm production for each alternative described in table 5 and resulted in direct impacts to cotton farming, grain farming, and other crop farming (forage production) in the study area.

Alternative 1

The industry specific direct impacts for *Alternative 1* are a $-1,263,192 decrease in cotton farming, a grain farming increase of $18,085, and other crop farming (forage production) increase of $2,691,313. Cumulative model outputs are presented in table 7; the total direct impact of *Alternative 1* was found to be $1,446,206. This increase in economic activity also generated an increase in demand for goods and services by those industries providing support functions to the three affected industries. An additional $57,764 of net economic activity in the study area was realized and results in other impacts on the local industries. These other impacts will be additional expenditures of new household income generated by the direct and indirect effects of final demand changes.

Table 7. Economic impacts of salinity reduction of Pecos River irrigation water

Alternative 1: Reduce cotton and wheat acres, increase alfalfa acres					
	Direct	Indirect	Induced	Total	Multiplier
Output	$1,446,206	$57,764	$225,901	$1,729,871	1.20
Value Added	$899,611	$28,915	$147,769	$1,076,295	1.20
Employment (Jobs)	2.9	-1.8	2.3	3.4	1.17
Total Economic Impact of Alternative 1				$2,806,166	1.20
Alternative 2: Maintain cotton acres, reduce wheat acres and increase alfalfa acres					
	Direct	Indirect	Induced	Total	Multiplier
Output	$815,378	$115,803	$111,480	$1,042,661	1.28
Value Added	$407,423	$65,793	$72,918	$546,134	1.34
Employment (Jobs)	5.1	1.6	1.1	7.8	1.53
Total Economic Impact of Alternative 2				$1,588,795	1.30

Employee compensation, proprietor income, other property income, and indirect business taxes are included in the value added row; the direct value added for *Alternative 1* was $899,611 and total value added equated to $1,076,295. The study area is expected to realize an increase of employment by 3.4 full time equivalent (FTE) employees under *Alternative 1* along with a total economic impact of $2,806,166. Total economic impact divided by total direct output provides a total impact multiplier of 1.20; meaning for every dollar of direct impact, $1.20 worth of total economic activity is generated.

Alternative 2

Alternative 2 yields industry specific direct impacts of a $49,440 increase in cotton farming, an $18,085 increase in grain farming, and a $747,853 increase in other crop farming (forage production). The economic impacts for this alternative are also reported in table 7. The total economic impact of this alternative is less than *Alternative 1*, but the multiplier effect of the direct impact is greater. For every dollar of economic impact resulting from this alternative, $1.30 of economic activity is generated. The employment impact is also greater for this alternative, creating an additional 7.8 FTE jobs.

Discussion

In order to develop realistic and comparable economic analyses, it was imperative to make fixed assumptions about water availability and crop mixes. Although this ‘fixed’ scenario is highly unlikely in the real world, it is necessary to conduct economic analyses. The 2005 parameters for irrigation water and usage from RBWPCD and CID appear to be a reasonable, average representation of past events and were used as the analysis baseline. Input-output model analysis measures the annual outcomes of industrial activity in an economy that are only valid for the modeled year.

In this analysis, *Alternative 1* created the largest cumulative impact to the six county study area. This scenario required a large shift in acreage from cotton to alfalfa; which in practice would not be a seamless transition and could take an extended period of time to complete. As a result, *Alternative 2* is a more likely outcome for the farming community. Alfalfa production likely requires more on-farm labor to swath, bale, and haul throughout the growing season relative to a similar number of cotton acres. Oil field activity in the study area over the last several years has made available labor scarce. This makes the decreased level of labor required for cotton production as compared to alfalfa production easier for the producer to acquire. Commercial scale alfalfa farms also require a considerable effort in marketing product while marketing channels for cotton are more structured and can be coordinated through local cotton gins or cooperatives. This may also cause some resistance to moving production away from cotton at the expense of the local gin. *Alternative 2* may be looked at as an interim position as salinity levels in the water are lowered, salts in the soils are leached from the crop root zones, business plans are altered, and crop rotations are modified to efficiently use their improved water resources.

The analysis assumed current infrastructure exists to handle this level of farming intensity. Although the Pecos River Basin has a reputation for producing quality melons and other vegetables, its reputation has largely been gained with better quality groundwater and as a result, increased production of these crops was not modeled. Discussions with producers and irrigation district personnel suggested there would not be a large increase in horticultural crops if salinity levels were decreased, as vegetable and melon production are already considered inherently high risk enterprises. The overall risk would be compounded with the uncertainty of available irrigation water. If large increases in irrigated acres or large shifts to vegetable or melon production are projected, an investment in infrastructure such as vegetable/melon packing sheds or gin capacity may be required; further increasing the need to adjust the economic model.

The uncertain prospects of having irrigation water available have discouraged investment by producers and irrigation districts along the Pecos River. As Lansford has suggested, top managers may have migrated to regions within the Pecos River Basin where quality groundwater is accessible and crop production and economic performance are less variable. Low equity producers and tightening credit availability may also limit the response to changes in the quantity and quality of irrigation water.

Summary/Recommendations

In order for the modeled economic scenarios to be feasible in the Pecos River Basin, the Salinity Alleviation Project near Malaga Bend must cost less than the generated economic impact. Therefore, if costs to operate and reduce salt intrusion at Malaga Bend exceed $2.8 million annually, *Alternative 1* becomes uneconomical or if costs exceed $1.6 million annually, *Alternative 2* is no longer viable.

Three interrelated factors contribute to limit the economic impact to the study area of any salinity control measures. The cumulative size of the district means that project costs will be spread over relatively few acres and delivery loss issues coupled with weather related variations in irrigation water allotments make planning and investment difficult for producers. Ultimately, such factors greatly increase risk to producers and deter producers from investing in modifications to current cropping regimes.

Alternative 1 shifts acres from both cotton and wheat to alfalfa production, resulting in a $2.8 million impact to the study area. The alternative increases the value of an acre foot of reduced salinity water by $211. *Alternative 2* maintains cotton acres, reduces wheat acres, and increases alfalfa acres. This alternative results in a $1.6 million impact to the study area; however, there is not a decrease in indirect demand for goods and services provided by study area cotton gins. Therefore, *Alternative 2* generates a greater multiplier effect and a better impact on employment. The reduction of salinity with *Alternative 2* increases value of water by $120 per acre foot.

It would be inappropriate to extrapolate values to a delivery system rehabilitation project in which the water saved could be measured and delivered to irrigators. Again, the unpredictable nature of irrigation allotments will also complicate the economic analysis of a rehabilitation project.

An update or new rehabilitation study of the diversions and delivery system of the Pecos River below Red Bluff also needs to be undertaken as a means to increase the chance that irrigators will invest in farm level infrastructure. Total delivery loss estimates amount to approximately 55 percent, this suggests a tremendous potential for cost effective gains in efficiency improvements.

The ethanol phenomena of the last couple years suggest the economic impacts and valuation of water are possibly understated. An updated analysis with current commodity and input prices may provide support for a large-scale salinity control project based on irrigation values of water.

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Appendix 1.

Output, Value Added, and Employment for the Upper Pecos Basin

Industry	Industry Output[2]	Employment	Employee Compensation[2]	Proprietor Income[2]	Other Property Income[2]	Indirect Business Tax[2]	Total Value Added[2]
Grain farming	0.254	9	0.005	0.072	0.04	0.005	0.121
Vegetable and melon farming	26.307	200	2.283	11.581	5.444	0.247	19.555
Tree nut farming	10.587	32	0.866	4.439	1.98	0.284	7.569
Fruit farming	2.116	19	0.34	0.549	0.323	0.046	1.258
Greenhouse and nursery production	3.409	59	1.939	1.167	-0.285	0.034	2.855
Cotton farming	5.567	53	0.487	0.7	0.864	0.051	2.102
All other crop farming	5.8	31	0.363	1.538	0.936	0.112	2.948
Cattle ranching and farming	48.321	615	2.126	0.328	1.363	1.016	4.833
Poultry and egg production	0.469	4	0.073	0.057	0.028	0.002	0.16
Animal production- except cattle and poultry	6.973	152	0.525	-0.119	0.271	0.108	0.785
Hunting and trapping	0.677	6	0	0.02	0.082	0.029	0.131
Agriculture and forestry support activities	4.035	160	2.888	0.119	-0.318	0.03	2.719
Oil and gas extraction	283.239	597	61.631	14.689	87.22	16.556	180.096
Stone mining and quarrying	6.09	23	3.354	0.002	0.22	0.028	3.604
Sand- gravel- clay- and refractory mining	17.353	77	6.16	0.974	3.255	0.464	10.853
Drilling oil and gas wells	119.926	193	9.597	4.001	20.916	4.555	39.068
Support activities for oil and gas operations	374.672	1,812	111.076	16.442	212.087	15.484	355.088
Power generation and supply	41.849	90	8.807	0	20.246	4.966	34.019
Natural gas distribution	31.218	53	5.239	0.018	2.912	2.67	10.839
Water- sewage and other systems	0.216	2	0.098	0	0.067	0.008	0.173
New residential 1-unit structures- all	36.831	253	7.76	2.735	1.369	0.187	12.052
New multifamily housing structures- all	3.974	37	1.108	0.4	0.32	0.011	1.838
New residential additions and alterations-all	5.206	30	0.915	0.313	0.649	0.026	1.904
Manufacturing and industrial buildings	1.614	19	0.602	0.202	0.041	0.009	0.855
Commercial and institutional buildings	20.492	220	6.788	2.345	1.034	0.125	10.293
Highway- street- bridge- and tunnel construction	4.392	42	1.357	0.464	0.352	0.028	2.201
Water- sewer- and pipeline construction	3.212	28	0.879	0.302	0.213	0.02	1.414
Other new construction	8.904	101	3.151	1.088	0.466	0.037	4.743
Maintenance and repair of farm and nonfarm residential buildings	1.806	13	0.415	0.143	0.013	0.008	0.579
Maintenance and repair of nonresidential buildings	6.586	56	1.745	0.601	0.151	0.046	2.544
Maintenance and repair of highways, streets, and roads	1.004	12	0.394	0.136	0.006	0.007	0.544
Other maintenance and repair construction	3.694	59	1.877	0.636	-0.214	0.022	2.321

Industry	Industry Output[2]	Employment	Employee Compensation[2]	Proprietor Income[2]	Other Property Income[2]	Indirect Business Tax[2]	Total Value Added[2]
Other animal food manufacturing	4.113	6	0.109	0.061	0.019	0.014	0.204
Frozen food manufacturing	21.032	83	1.698	0.035	1.272	0.081	3.086
Tortilla manufacturing	0.382	3	0.047	0.007	0.033	0.002	0.089
All other food manufacturing	16.572	69	1.747	0.03	0.356	0.061	2.194
Soft drink and ice manufacturing	77.391	134	3.71	0.264	2.141	0.271	6.386
Wineries	5.666	19	0.498	0	0.009	0.251	0.758
Textile bag and canvas mills	1.022	9	0.13	0	0.018	0.002	0.15
Cut and sew apparel manufacturing	0.163	2	0.008	0.015	0.009	0.001	0.032
Commercial printing	0.396	4	0.048	0.192	0.041	0.004	0.285
Petroleum refineries	19.818	1	0.03	4.231	4.483	0.318	9.061
Asphalt paving mixture and block manufacturing	3.97	2	0.079	2.163	0.231	0.048	2.521
Tire manufacturing	1.164	3	0.012	0.534	0.035	0.019	0.6
Ready-mix concrete manufacturing	0.345	1	0.023	0.052	0.049	0.004	0.128
Ferrous metal foundaries	5.879	27	1.83	0.023	0.581	0.048	2.482
Fabricated structural metal manufacturing	3.952	15	0.841	0	0.597	0.023	1.461
Machine shops	1.152	9	0.437	0	0.053	0.008	0.497
Farm machinery and equipment manufacturing	2.116	5	0.117	0.183	0.208	0.004	0.512
Travel trailer and camper manufacturing	5.973	22	0.909	1.595	0.078	0.043	2.626
Wholesale trade	42.012	298	15.878	0.056	6.202	6.197	28.332
Air transportation	1.777	12	0	0.022	0.001	0.002	0.024
Rail transportation	0.954	3	0.358	0	0.249	0.019	0.626
Water transportation	0.929	2	0	0.09	0.089	0.015	0.194
Truck transportation	54.542	349	21.579	0.34	6.199	0.636	28.754
Transit and ground passenger transportation	0.451	8	0.199	0.006	0.066	0.011	0.281
Pipeline transportation	99.638	147	20.382	0.285	9.795	6.322	36.784
Scenic and sightseeing transportation and supplies	4.281	11	0.345	2.65	-0.103	0.509	3.401
Postal service	4.361	79	3.178	0	0.143	0	3.32
Couriers and messengers	0.149	9	0	0.017	0.007	0.001	0.024
Motor vehicle and parts dealers	16.551	185	6.34	1.257	0.809	2.377	10.783
Furniture and home furnishings stores	4.4	68	1.307	0.243	0.525	0.613	2.687
Electronics and appliance stores	0.073	3	0.007	0.039	0.002	0.011	0.06
Building material and garden supply stores	6.155	91	1.802	0.416	0.518	0.835	3.571
Food and beverage stores	21.605	392	8.652	0.649	1.608	2.387	13.296
Health and personal care stores	14.944	194	7.043	0.123	0.463	2.215	9.843
Gasoline stations	20.868	341	5.405	1.07	4.772	3.033	14.28
Clothing and clothing accessories stores	5.451	110	1.597	0.168	1.028	0.793	3.586
Sporting goods- hobby- book and music stores	1.116	29	0.32	0.13	0.062	0.158	0.671
General merchandise stores	18.858	382	7.526	0.113	0.519	2.598	10.757

Industry	Industry Output[2]	Employment	Employee Compensation[2]	Proprietor Income[2]	Other Property Income[2]	Indirect Business Tax[2]	Total Value Added[2]
Miscellaneous store retailers	1.318	54	0.342	0.368	0.086	0.193	0.989
Non-store retailers	2.117	45	0.278	0.159	0.895	0.24	1.573
Newspaper publishers	3.864	42	1.27	0.226	0.457	0.026	1.979
Radio and television broadcasting	2.039	13	0.335	0.153	-0.003	0.006	0.491
Cable networks and program distribution	0.645	1	0.012	0.001	0.063	0.004	0.08
Telecommunications	19.791	75	2.906	0.525	3.654	1.182	8.268
Information services	3.139	15	0.391	0.036	0.172	0.014	0.613
Non-depository credit intermediation and related	7.946	82	2.638	0.23	1.203	0.312	4.383
Securities, commodity contracts, investments	4.236	42	0.612	0.67	-0.186	0.033	1.129
Insurance carriers	2.005	11	0.26	0.098	0.118	0.059	0.535
Insurance agencies, brokerages, and related	5.169	72	1.976	0.246	2.162	0.028	4.412
Funds- trusts- and other financial vehicles	0.725	3	0.006	0.053	-0.003	0.003	0.059
Monetary authorities and depository credit institutions	53.204	349	12.489	0.467	24.404	0.681	38.041
Real estate	16.148	85	2.119	0.608	6.627	1.978	11.332
Video tape and disc rental	3.752	56	1.077	0.27	0.443	0.169	1.959
Machinery and equipment rental and leasing	38.592	104	7.403	0.362	9.726	0.609	18.1
General and consumer goods rental except videos	0.324	7	0.151	0.005	-0.001	0.003	0.158
Legal services	14.306	121	4.404	2.893	1.614	0.281	9.192
Accounting and bookkeeping services	13.251	150	4.849	1.376	0.357	0.053	6.635
Architectural and engineering services	8.024	76	2.959	0.959	-0.012	0.032	3.938
Custom computer programming services	0.347	5	0.162	0.161	-0.029	0.002	0.295
Computer systems design services	0.527	10	0.263	0.21	-0.026	0.011	0.458
Management consulting services	1.333	11	0.333	0.275	0.011	0.005	0.624
Environmental and other technical consulting	7.589	47	1.675	1.168	0.869	0.025	3.738
Scientific research and development services	0.169	2	0.047	0.045	-0.012	0.001	0.081
Advertising and related services	1.982	17	0.475	0.22	0.055	0.012	0.763
Veterinary services	4.369	65	1.395	0.378	-0.191	0.091	1.673
All other miscellaneous professional and tech	0.293	1	0.01	0.008	0.064	0.002	0.083
Management of companies and enterprises	1.938	17	0.586	-0.002	0.157	0.012	0.752
Employment services	1.542	56	1.285	0.031	-0.018	0.007	1.306
Business support services	0.794	14	0.258	0.099	0.081	0.016	0.454
Investigation and security services	2.396	40	1.517	0.126	0.153	0.042	1.838
Services to buildings and dwellings	2.801	79	0.603	0.128	0.146	0.032	0.909
Other support services	0.623	8	0.13	0.024	0.122	0.007	0.282
Waste management and remediation services	1.036	6	0	0.291	0.198	0.044	0.533
Elementary and secondary schools	0.955	54	0	0.25	-0.001	0	0.249
Home health care services	2.993	84	1.287	0.291	0.237	0.011	1.825
Offices of physicians- dentists- and other he	23.101	377	8.318	4.559	2.146	0.133	15.156

Industry	Industry Output[2]	Employment	Employee Compensation[2]	Proprietor Income[2]	Other Property Income[2]	Indirect Business Tax[2]	Total Value Added[2]
Other ambulatory health care services	0.45	3	0.146	0.019	0.059	0.003	0.228
Nursing and residential care facilities	11.965	292	6.754	0.058	0.146	0.163	7.121
Child day care services	0.653	17	0.241	0.01	0.151	0.005	0.407
Social assistance except child day care services	1.176	33	0.692	0.014	-0.017	0.005	0.693
Performing arts companies	2.558	154	0	0.696	-0.145	0.079	0.63
Museums- historical sites- zoos- and parks	2.769	51	0.708	0.695	-0.234	0.031	1.201
Fitness and recreational sports centers	0.44	27	0.012	0.078	-0.001	0.013	0.102
Other amusement, gambling and recreation industry	1.69	55	0.134	0.245	0.218	0.092	0.69
Hotels and motels- including casino hotels	9.356	177	2.813	0.477	1.674	0.851	5.814
Other accommodations	0.616	8	0.113	0.005	0.078	0.017	0.214
Food services and drinking places	42.515	970	12.35	0.302	3.426	1.877	17.955
Car washes	0.949	21	0.247	0.056	0.188	0.056	0.547
Automotive repair and maintenance- except car	14.572	167	4.851	0.719	0.507	1.185	7.262
Electronic equipment repair and maintenance	0.955	6	0.281	0.026	0.149	0.035	0.491
Commercial machinery repair and maintenance	16.61	136	3.671	1.448	2.559	0.556	8.234
Personal care services	0.076	2	0.008	0.018	0.009	0.003	0.037
Death care services	1.469	35	0.26	0.269	0.004	0.089	0.621
Dry cleaning and laundry services	1.114	46	0.151	0.249	0.013	0.05	0.462
Other personal services	0.795	6	0.031	0.065	0.175	0.031	0.302
Religious organizations	0.071	1	0.006	0.002	0.019	0	0.027
Civic- social- professional and similar organ	10.092	330	5.568	0.116	-1.281	0.028	4.431
Private households	3.698	460	2.669	1.612	-0.584	0	3.698
Other Federal Government enterprises	0.089	4	0.079	0	-0.02	0	0.059
State and local government passenger transit	1.703	27	1.379	0	-0.762	0	0.616
State and local government electric utilities	6.056	16	1.175	0	1.883	0.016	3.074
Other State and local government enterprises	39.126	202	7.438	0	5.46	0.004	12.903
State & Local Education	123.205	3,169	112.983	0	10.221	0	123.205
State & Local Non-Education	92.571	1,918	84.891	0	7.68	0	92.571
Federal Military	5.734	100	5.203	0	0.532	0	5.734
Federal Non-Military	10.791	78	10.024	0	0.767	0	10.791
Owner-occupied dwellings	119.933	0	0	0	92.908	14.181	107.09
Totals	2,353.43	18,990	688.742	108.146	583.977	102.878	1,483.74

Appendix 2.

Pecos River Rangeland Manager Survey

A Component of: Task 1.7, Economic Modeling of Pecos River Basin and Assessment of Saltcedar Control Activities

William Thompson
Texas AgriLife Research and Extension Center - San Angelo

August 2008

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Summary

This survey attempts to evaluate the economic benefit realized by landowners along the Pecos River who utilize it as a livestock ranching resource. In terms of water use, livestock operations represent a small segment of the agricultural economy of the Pecos River Basin; irrigation is the largest user of water from the Pecos River. To this point, little economic benefit or value as a result of saltcedar control has been realized by landowners who are managing livestock ranch lands crossed by the Pecos River. Other social or environmental benefits of saltcedar control may be experienced, but are likely to be seen downstream at Amistad International Reservoir or the Rio Grande.

Introduction

Control of Tamarix (saltcedar) often focuses on the prospects of increased stream flows, increased water yields, and improved water quality within rivers and tributaries. Saltcedar control measures on the Pecos River have similarly focused on these same issues; however, the Pecos River Basin Assessment Project, as part of its development of a watershed protection plan, has also incorporated an inventory of wildlife and aquatic life and other hydrologic studies of the river and its tributaries in addition to saltcedar control. Irrigated crop production is one of the largest users of water from the Pecos River; therefore, the salvage of water and its impact on the farming economy is a logical analysis.

The overwhelming percentage of land in the Pecos River Basin is considered Chihuahuan Desert rangeland. The land immediately adjacent to the river is also mostly rangeland and is used by area ranchers as grazing lands for cattle, sheep, and goats. Hunting and other recreational activities have become significant sources of cash flow for area landowners and managers.

A survey was sent to landowners and land managers along the Pecos River to assess the economic impact they have experienced as a result of saltcedar control along the Texas portion of the Pecos River.

Methods

A list of landowners/managers along the Pecos River was assembled for the purpose of collecting perceptions of the economic value of saltcedar control efforts. Only landowners or managers residing within the Pecos River Basin were selected to receive the survey in an attempt to gather information from those that have first-hand knowledge of both saltcedar control measures and the long term and often subtle responses of the river.

An initial direct mailing of surveys took place on June 22, 2007. A total of 220 surveys were mailed, with 27 surveys returned as undeliverable. A postcard reminder was then mailed to the survey recipients on July 9, 2007. A total of 27 responses were returned for a 14 percent response rate (27/194). For the purposes of this analysis, the Texas portion of the Pecos River Basin was segmented into three river reaches along county boundaries. The upper basin region consists of Loving, Reeves, and Ward Counties; the middle basin consists of Crane, Crockett, Pecos, and Terrell Counties; and the lower basin is comprised of Val Verde County. Table 1 presents a summary of the responses by county within the respective portion of the overall basin. These responses represent approximately 31 percent of the 418 Pecos River miles in Texas (Jensen et al. 2006). Of the 27 responses, only 12 respondents made estimates of the number of acres sprayed. These estimates accounted for 5,241 acres of saltcedar treated on 52.25 river miles, or 100.3 acres per river mile. Two of these responses claimed 4,500 acres of treated saltcedar in 8.5 river miles which may be an over estimation. Removing these responses yields 741 treated acres within 43.75 river miles, or 16.93 acres per river mile.

Table 1. Summary of Pecos rangeland manager survey

Upper Basin			Middle Basin			Lower Basin		
County	**Responses**	**River Miles**	**County**	**Responses**	**River Miles**	**County**	**Responses**	**River Miles**
Loving	1	9	Crane	1	8	Val Verde	2	10
Reeves	5	34	Crockett	6	34			
Ward	9	16.125	Pecos	6	14.75			
			Terrell	2	4			
Totals	15	59.125		15	60.75		2	10

Results

Reclamation and Regeneration of Treated Areas

Chemical treatment of saltcedar along the Pecos River began in 2001; as of 2006, over 13,500 acres of saltcedar were treated along the Pecos River and its tributaries (Sheng et al. 2007). Therefore, landowners and managers have had an opportunity to witness some re-vegetation of the treated riparian areas, and where applicable, initiate desired reclamation efforts. Reclamation efforts could include piling and or burning debris, reseeding, and spot treatment of re-invading plant species.

All respondents claimed to have incurred no debris removal or reclamation costs on acres treated for saltcedar. To date, 71 percent of respondents could identify the most common plant type coming back into the treated areas; the majority of returning plant species have been grasses. Table 2 summarizes data on returning plant species in the treated areas.

Table 2. Returning plant types and species witnessed in treated areas

Returning Plant Types								
Woody Plants			**Grasses**			**Forbs**		
38% (N=8)			52% (N=11)			10% (N=2)		
Returning Plant Types by Basin								
Upper Basin			Middle Basin			Lower Basin		
Woody Plants	Grasses	Forbs	Woody Plants	Grasses	Forbs	Woody Plants	Grasses	Forbs
N=3	N=6	N=1	N=5	N=5	N=1	0	0	0
Witnessed Plant Species								
Mesquite	Saltgrass (2)		Willow (2)	Bermuda (2)				
Saltcedar	Bermuda		Saltcedar	Saltgrass (2)				
			Mesquite (2)	Plains Bristle				
				Buffalo				

Economic Value and Change

Only two respondents (6 percent) claimed to have experienced a positive net economic value by the change experienced as a result of saltcedar control measures. Cumulatively, these two respondents claim an economic net benefit of $545.45 per river mile which they attributed to recreational activities (hunting and wildlife habitat). Table 3 summarizes the anticipated changes in the next five years resulting from the saltcedar control. Decreases in economic value were attributed to the accumulation of debris.

Table 3. Expected change in five years in economic value of Pecos River as a result of saltcedar control (n=32)

Expected Change in Economic Value	Upper Basin	Middle Basin	Lower Basin	Percent Total of Respondents
Increase in Economic Value	10	6	1	56%
No Change	4	7	1	38%
Decrease in Economic Value	0	2	0	6%

Management, Water Quality and Water Quantity

Landowners and managers were asked to identify changes in their existing or new management practices adopted because of changing conditions along the treated riparian areas. More than half (56 percent) of the respondents have made no changes to their management practices on the treated riparian areas or the adjacent rangelands. Table 4 summarizes the remaining 44 percent of respondents.

Table 4. Summary of adopted or changed management practices as a result of saltcedar control (n=36)

Adopted/Changed Practice	Upper Basin	Middle Basin	Lower Basin	Percent (%) of Total Responses
Stocking rate	2	2		11
Erosion control	2	3		14
Grazing species management	1	2		8
Treatment of returning species	0	3		8
Reseeding of treated areas	0	1		3
No change	11	8	1	56

Changes to stocking rate can include both increasing and decreasing of historical stocking rate. If saltcedar is controlled and other beneficial plant types are reestablished, stocking rates could theoretically be increased. Similarly, erosion concerns may limit stocking rates until returning vegetation is well established. Erosion control measures were not specified, allowing land managers to define their own activities. Grazing species management could involve a complete change in the species being grazed on or adjacent to treated areas, or could simply be a change in the mix of species grazed. Treatment of returning plant species was not defined, but could include chemical or mechanical treatment of weeds, or regenerating woody species such as mesquite or saltcedar. Reseeding was intended to be limited to areas with suitable grasses for forage production and erosion control.

Table 5 summarizes landowner and manager perceptions of changes to water quantity in their respective portions of the river. These responses are subjective opinions of the surveyed landowners and managers and are not based on collected flow data. The table reports the number of responses and percentages of survey responses within each portion of the Pecos River Basin.

Table 5. Perceived changes to water quantity (percent of responses)

	Surface Water			Groundwater		
	Upper Basin	**Middle Basin**	**Lower Basin**	**Upper Basin**	**Middle Basin**	**Lower Basin**
Increase	1 (7%)	8 (53%)			4 (27%)	
No Change	13 (93%)	7 (47%)	1 (100%)	1 (100%)	11 (73%)	1 (100%)
Decrease						

Table 6 summarizes landowner and manager perceptions of changes to water quality in their respective reaches of river. These responses are also subjective opinions of the surveyed landowners and managers and are not based on collected water quality data. The table reports the number of responses and percentages of survey responses within each portion of the Pecos River Basin.

Table 6. Perceived Changes to Water Quality (total responses and percent of responses).

	Surface Water			Ground Water		
	Upper Basin	**Middle Basin**	**Lower Basin**	**Upper Basin**	**Middle Basin**	**Lower Basin**
Increase	1 (7%)	4 (27%)			2 (13%)	
No Change	13 (93%)	11 (73%)	1 (100%)	14 (100%)	12 (80%)	1 (100%)
Decrease					1 (7%)	

Wildlife

Most respondents have not seen an increased use of the treated riparian areas by wildlife; however, some have noted increases and decreases of various species. Table 7 summarizes the perceived changes to wildlife utilization of the treated areas.

Table 7. Perceived changes to wildlife use (total responses and percent of total responses)

Basin		Predators	Gamebirds	Deer	Feral Hogs
Upper Basin	Increase	2 (14.3%)	4 (28.6%)	3 (21.4%)	3 (21.4%)
	No Change	10 (71.4%)	8 (57.1%)	9 (64.3%)	9 (64.3%)
	Decrease	2 (14.3%)	2 (14.3%)	2 (14.3%)	2 (14.3%)
Middle Basin	Increase	4 (26.7%)	8 (53.3%)	8 (53.3%)	3 (20.0%)
	No Change	10 (66.7%)	6 (40.0%)	6 (40.0%)	11 (73.3%)
	Decrease	1 (6.7%)	1 (6.7%)	1 (6.7%)	1 (6.7%)
Lower Basin	Increase				
	No Change	2 (100%)	2 (100%)	2 (100%)	2 (100%)
	Decrease				

Restoration/Reclamation Costs

Survey recipients were asked if they expected to incur any reclamation or restoration costs in the next three to five years. A large majority of respondents (74 percent) did not expect to incur these costs. One respondent from the upper portion of the river basin did expect to incur $500 of reclamation expenses for chemically re-treating a one mile stretch of the river. There were no responses to this question from the lower portion of the river basin. Table 8 summarizes the costs that are expected for the middle portion of the Pecos River Basin. For this purpose, chemical treatment was not defined, allowing respondents to define these expenses as re-treatment of saltcedar or the treatment of other plant types returning to the riparian areas. Mechanical treatments include piling debris for later burning or the removal (grubbing) of remaining saltcedar. One respondent is claiming that dead saltcedar is collapsing on and destroying fence tha will need to be replaced.

Table 8. Restoration/reclamation costs expected by owners or managers of treated areas in the middle portion of the Pecos River basin.

			Expected	
	No. of responses[5]	**River miles**	**Total cost**	**Cost/river mile**
Chemical Treatment	4	11.5	$12,200	$1,061
Mechanical Treatment	2	7	$10,800	$1543
Controlled Burn	2	17	$6,500	$382
Replacement Fence	1	2.5	$15,000	$6,000

[1] Two respondents expect to incur costs in more than one category.

Discussion

Overall, landowners and managers along the Pecos River have realized little economic benefit or value from the treatment of saltcedar along the Pecos River. This result is not entirely unexpected as it takes time for the process of treating, removing debris, and re-vegetation to occur. Despite the fact that grasses are the most common plant type seen returning to the treated areas, the relatively small number of acres treated per river mile, and the natural carrying capacity of Chihuahuan desert rangeland suggest that it will require several treated river miles to produce enough forage to support a single additional animal unit (AU). The low quality of water within the Pecos River between Red Bluff and Girvin also limits the economic value of saltcedar control to ranchers. This water is often times considered to be of limited or very limited use for livestock (Miyamoto et al., 2007, Ayers et al., 1985). Fee based recreational activities have become a significant source of gross income for many Trans-Pecos ranches (Medeiros and Anderson, 2007) and may become more important in the future; however, until additional debris is removed and access is further increased it is not likely that rangeland managers will realize a greater economic value to saltcedar control from hunting or other recreational activities. It should be noted that 56 percent of landowners/managers do expect to realize some economic benefit from saltcedar treatment within the next five years.

Similarly, it may be too early to assess changes in management practices along the Pecos River. As debris is removed from the riparian areas through burning or mechanical means, producers may begin to implement new or different management patterns. Management strategies employed by some landowners or managers may also change if levels of permitted access to the river change.

Seventy-four percent of respondents did not expect to incur any reclamation or restoration costs, though numerous references were made by respondents about the need for debris removal. It appears that landowners and managers will wait for government sponsored and/or cost share programs to initiate large scale debris removal efforts.

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