The Edwards Aquifer Water Resource Conflict: Examining Impacts of USDA Programs[1]

By

Glenn D. Schaible, Ronald D. Lacewell, and Bruce A. McCarl[2]

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[2] **Glenn D. Schaible is an Agricultural Economist with the Economic Research Service, USDA, Washington, DC. Ronald D. Lacewell and Bruce A. McCarl are Professors with the Department of Agricultural Economics, Texas A&M University, College Station, Texas.**

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Abstract

This paper summarizes results of economic analysis of the impact 1990 and 1996 USDA Farm Programs have on irrigation water withdrawals from the Edwards Aquifer (of south-central Texas). Economic modeling, a producer behavioral survey, characteristics of program participating farms, and economic theory are used to explain producer irrigation behavior.

The San Antonio Segment of the Edwards Aquifer of south-central Texas is an annually recharged aquifer, depending on rainfall, that is also the primary water-supply source for both human and endangered species water-resource demands. The aquifer is the water-supply source for about 1.3 million people (including the city of San Antonio), many rural and municipal water-supply systems, military bases, about 80,000 acres of irrigated agricultural land, livestock production, and water-based recreation along Comal and San Marcos Rivers at the eastern end of the aquifer.[1] Human water demands from the aquifer creates a human/-endangered species water-use conflict because it is feared by some that withdrawals for human demands could at some point reach a level that exceeds the ability of the aquifer to be replenished through natural recharge; resulting in reduced aquifer levels that can impair the habitat and survival of Federally-listed threatened and endangered species at Comal and San Marcos Springs (located just east of San Antonio) or within associated River ecosystems.[2]

Current levels of annual water withdrawals (human demand) may be related to a reduction in the aquifer water table which reduces aquifer discharge through several springs,

[1] The Edwards Aquifer Region covers portions of or all of 15 counties, however, the artesian portion of the San Antonio Segment within Kinney, Uvalde, Medina, and Bexar counties flows from west to east, and then to the northeast within Bexar, Comal, and Hays counties.

[2] Federally-listed species include two species of fish, the San Marcos gambusia and the fountain darter; one plant, the Texas wild-rice; and two salamanders, the Texas blind salamander and the San Marcos salamander. All are listed as endangered, except the San Marcos salamander, which is listed as threatened. Proposed listed-endangered species include the Peck's cave amphipod, the Comal Springs riffle beetle, and the Comal Springs dryopid beetle.

but principally Comal and San Marcos Springs. Aquifer drawdown then, is related to endangered species habitat and the ability of aquifer-dependent species to survive, particularly during recurring drought years when reduced natural aquifer recharge occurs (U.S. FWS, 1996). Estimated annual aquifer discharges averaged 730.6 thousand acre-feet from 1955-1994; 49.2 percent through groundwater pumpage, and 50.8 percent through spring flows (EUWD, 1995). Estimated annual aquifer recharge averaged 676.6 thousand acre-feet for the period of record (1934-94), but ranged from 43.7 thousand acre-feet in 1956 (the most severe drought of record) to 2,486.0 thousand acre-feet in 1992 (USGS, 1995).

Aquifer drawdown due to human demands is also perceived by some to have a potential for causing deterioration of water quality in the aquifer and within Comal and San Marcos ecosystems, while also affecting water quality within the downstream Guadalupe River ecosystem (including its Texas Gulf Coast bays and estuaries). Groundwater pumpage for current human demands, particularly in severe drought years, is feared capable of deteriorating aquifer water quality if reduced aquifer water levels cause the saline or brackish (bad) water line, which borders the aquifer from the south and east, to move into the fresh water portion of the Edwards Aquifer (U.S. FWS, 1996). While this relationship remains unproven, it is feared that reduced aquifer water quality would affect water supplies for human use and for species habitat, both within the Edwards region and within its downstream ecosystems.

Withdrawals for irrigated agriculture is perceived by some to contribute to declining spring flows and the human/endangered species resource conflict, particularly during low rainfall years (U.S. FWS, 1996), even though this relationship also remains unproven. Average annual withdrawals from the aquifer for irrigated agriculture have increased from 73.8 to

119.9 thousand acre-feet (62.5 percent) between 1960-69 and 1985-94, but declined slightly as a share of total withdrawals for human use, from 27.6 to 26.7 percent (EUWD, 1995). Annual withdrawals for irrigation, however, have ranged from 59 to 204 thousand acre-feet, depending on rainfall (Moore and Votteler, 1994). Withdrawals for irrigated agriculture occurs primarily in the western aquifer region (Uvalde, Medina, and Bexar counties),[3] where the principal irrigated crops are cotton, corn, sorghum, peanuts, hay, and vegetables.

Because of USDA's involvement with agriculture in the western aquifer region, USDA decided to enter into "informal consultations" with the U.S. FWS to determine whether its' programs adversely affect aquifer-dependent threatened and endangered species and/or their habitat. USDA completed two Endangered Species Act (ESA) Biological Evalu-ations (BE's)[4] of its programs implemented in the three county area, assessing USDA program impacts on aquifer withdrawals for irrigated agriculture, and then on spring flows and aquifer-dependent threatened and endangered species. These studies included a BE of USDA programs under the amended 1990 Food, Agriculture, Conservation and Trade Act (USDA, March 1996), and a BE of USDA programs under the 1996 Federal Agriculture Improvement and Reform Act (USDA, forthcoming 1997). This paper summarizes the research approach of each study and their principle findings, with special emphasis given to the economic assessments of the irrigation water use impacts of the 1990 Farm Act's commodity programs and the 1996 Farm Act's production flexibility contract (PFC) payment program.

[3] This western region accounts for 99 percent of Edwards irrigation water pumpage.

[4] An ESA term, defined to include an economic assessment of program/activity impacts.

USDA's Edwards Aquifer BE Research Approach

USDA's evaluation of the impact of the 1990 Farm Act on aquifer water supplies involved four areas of analysis (USDA, March 1996). First, USDA conducted an inventory of program activity of farmer assistance (commodity and conservation) and rural development programs implemented in Uvalde, Medina, and Bexar counties (study area) for the period 1992-94. Second, economic analysis evaluated the impact of commodity programs on irrigated crop production from two analytic perspectives, an economic-efficiency and a producer behavioral/economic analysis. Economic-efficiency analysis involved using a discrete stochastic, mathematical economic model of irrigated agriculture for the study area (variation of McCarl et al., 1993) to evaluate the impact on irrigated production/water use for three alternative weather-year conditions under three crop-price scenarios, and each of these scenarios both with and without USDA commodity programs in effect for the study area. Crop price conditions involved crop market prices and associated deficiency payments and acreage set-aside requirements for 1992-94. Weather-year scenarios were defined for dry, wet, and normal conditions for the study area by evaluating Palmer's Drought Severity Index values for the period 1895 - 1995. Weather-year probabilities were used to reflect the stochastic character of irrigated production by incorporating the uncertainty of weather within the crop-mix decision.

The producer behavioral/economic analysis used results from a survey of producers irrigating cropland in the study area to assess: 1) behavioral differences between participating and nonparticipating irrigators; 2) what participating irrigators would have done in 1994 without USDA commodity programs; 3) the degree of importance of non-price factors affecting

irrigation and commodity program participation decisions, relative to market price and program benefits; and 4) whether USDA programs affect producer decisions to irrigate, or their intensity of irrigation water use.[5] The producer behavioral survey was conducted because: 1) farmers who irrigate crops in the Edwards area, but who do not participate in commodity programs, reflect producer judgements on the "economic efficiency" of crop irrigation without program benefits; and 2) producers, when making production decisions, recognize perceived values for irrigated/dryland productivity differences, Texas water-rights institutions, and a host of other non-price factors that act to influence the economically-rational behavior of Edwards irrigators with or without USDA program benefits.

Third, USDA's BE included a program-specific analysis (for programs implemented within the study area) using information from the program inventory, producer survey, and the economic modeling analysis to evaluate the impact of USDA programs on water-use demand and aquifer withdrawals. Fourth, USDA's BE of the 1990 Farm Act included an aquifer hydrologic-simulation analysis which evaluated the impact of alternative irrigation pumpage scenarios on spring flow (both discharge and duration) at Comal and San Marcos Springs.[6]

Economic analysis for USDA's BE of the 1996 Farm Act emphasized: 1) the impact of

[5] The Producer Behavioral Survey was conducted by USDA's National Agricultural Statistical Service (NASS), through the Texas Agricultural Statistics Service (TASS). The questionnaire was pre-mailed to a complete TASS list frame of farm operations in the study area. Data was subsequently col-lected via a telephone interview by TASS staff. Out of 1,864 farm contacts, 996 indicated positive crop-land, 369 had zero cropland, while 499 producers were either inaccessible (16.8%), out-of-business (5.3%), or refused to participate (4.7%). Only 224 out of the 996 respondents irrigated cropland.

[6] Hydrologic simulation analyses were conducted using: 1) the Texas Water Development Board's **Edwards Balcones Fault Zone Aquifer Flow Model**; and 2) the Texas Water Resources Institute's **Lumped Parameter Model for the Edwards Aquifer**. These results are not reported here because of space limitations.

the Act's production flexibility contract (PFC) payment program on study-area producer irrigation decisions; 2) the impact of study-area farm structural characteristics and a newly established aquifer-management institution, the Edwards Aquifer Authority (EAA), on irrigation investment and aquifer withdrawals; and 3) the impact of uncertainty on producer irrigation well-investment decisions (USDA, forthcoming 1997). Economic analysis of the impact of the PFC payment program included: 1) using economic modeling results from USDA's initial BE analysis to identify irrigation water use both with and without commodity-program benefits;[7] and 2) using producer survey results to evaluate the economic-efficiency behavior of irrigators with/without program benefits and the relative importance of market-based economic and other non-price factors in determining producer irrigation decisions. Data on the characteristics of PFC participating farms (Guy, 1996), including data on production, acres, PFC payments, and land ownership, particularly farm-tenure arrangements (owner-operator, cash-lease, or share-rental), and the irrigation well and aquifer-withdrawal management responsibilities of the EAA were assessed for their effect on new irrigation-well investments. Finally, economic theory and findings of the economic literature on investments under uncertainty are used to explain the likelihood of PFC payments being used for new well invest-ments given the increased economic uncertainty of such investments due to EAA existence.

Principle Economic Study Results of USDA's Edwards Aquifer BE Analyses

Findings of the Economic Modeling Analysis. Commodity program benefits under the 1990 Farm Act or PFC payments under the 1996 Farm Act do not encourage Edwards area

[7] PFC payments under the 1996 Farm Act are decoupled from (not tied to) actual crop produc-tion, that is, participating producers receive their PFC payment regardless of their crop production deci-sions. The PFC program then, characterizes a "no commodity program" or "without program" scenario.

producers to irrigate crops, or to increase irrigation intensity (per acre water use). These decisions are made on the basis of market-economic factors, including crop market prices, dryland/irrigated productivity differences, water-resource availability, and production input costs (USDA, Appendix III, March 1996). Program benefits under both farm programs are correctly characterized as farm income supplements that do not influence production-level or input-use decisions. Provisions under the 1990 Farm Act decoupled commodity deficiency payments from actual crop yield, and the 1996 PFC payment program does not require that any crop be grown for the producer to receive the PFC payment. Program provisions then effectively removed program benefits as a production-level decision incentive. While provisions of the 1990 Farm Act did require that a commodity crop be grown for a producer to collect the deficiency payment, this requirement only affected the farm's crop mix, but had no effect on the decision to irrigate a specific crop or its associated intensity of irrigation.

Economic model simulation results also demonstrate that: first, the region's irrigated cropping pattern is relatively stable, that is, while the crop-price levels between 1992-94 influenced the region's crop mix, crop price changes during 1992-94 had no dramatic impact on irrigation decisions. Market-economic factors essentially determine that crop irrigation is a relatively stable component of the region's aggregate cropping pattern. Second, modeling results further indicate that for all three crop price scenarios, under all three weather-year conditions (dry, normal, or wet), Edwards-area producers continue to irrigate program and nonprogram crops at the same intensity, even without commodity program benefits. In the absence of the 1990 Farm Program, producers would irrigate fewer acres of cotton, grain sorghum, and wheat, but irrigate more acres of corn, oats, hay, and vegetables. In addition,

producers would shift program set-aside acres back into irrigated production.

In the absence of the 1990 USDA commodity programs then, Edwards producers increase pumpage from the aquifer because producers shift crop irrigation to more water-consuming crops and to more extensive-margin irrigation. Irrigation pumpage without USDA commodity programs increases across price scenarios from: 1) 8 to 16 thousand acre-feet (4.8 to 10.5%) under normal (average) weather-year conditions; 2) 14 to 18 thousand acre-feet (10.3 to 14.0%) under wet weather-year conditions; and 3) 3 to 8 thousand acre-feet (1.7 to 4.6%) under dry weather-year conditions. Therefore, even though net farm income declines for the area without commodity programs, from $1.0 to $2.8 million (7 to 27%) depending on the weather-year condition, market-based economics increases irrigation pumpage. USDA commodity program benefits then, did not cause irrigation pumpage to increase, but rather, commodity programs reduced irrigation withdrawals from the Edwards Aquifer.

USDA's analysis of the impact of the 1996 Farm Act (USDA, forthcoming 1997) also indicated no effect on Edwards irrigation pumpage because the PFC payment program, which serves only as a farm-income supplement program, effectively characterizes a "without program" scenario. Increased irrigation pumpage under the new Farm Act then, will not be due to any program-based, commodity production incentive, but rather, increased pumpage will occur because market economic signals are the critical factors driving irrigation decisions.

Findings of the Producer Behavioral/Economic Analysis. Behavioral survey results reveal: 1) the economic-efficiency of crop irrigation without commodity program benefits; 2) that Edwards producers will continue to plant and irrigate program and non-program crops without program benefits; and 3) that market-economic factors dominate irrigation decisions

(USDA, Appendix II, March 1996). First, only 34% of study area irrigators were program participants in 1994, while 66% of irrigators irrigated program and nonprogram crops without program benefits. Participating irrigators emphasized irrigating corn, cotton, and sorghum (70.4% of their total irrigated acres), while nonparticipants emphasized irrigating corn, oats, hay, and vegetables (79.7% of their total irrigated acres). The region's weighted average program participation rate across all irrigated acres is 42.4%, while for irrigated acres for program crops alone, 57.2% were participating and 42.8% nonparticipating. Participating irrigators irrigated 57.8% of their cropland and nonparticipants irrigated 55.8% of their cropland. In addition, 75% of nonparticipants using ground water indicated that they have not "ever considered participating in USDA commodity programs". Producer-based, irrigation production and program participation decisions then, highlight the significance of the economic efficiency of irrigation of commodity program crops without USDA program benefits.

Second, survey results demonstrate the existence of a "core" irrigated crop mix for the area. Participating irrigators reported they would have irrigated 97% of the acres they irrigated, even if commodity programs had not existed in 1994. These irrigators would have shifted irrigation into corn, cotton, oats, and wheat. In addition, 75 to 96% of participating irrigators apply "about the same" water per acre when participating in a commodity program, i.e., participation does not cause water-use changes at the intensive margin. A core irrigated crop mix for the area then, means that irrigation water use would at least remain nearly the same, possibly increase, but was unlikely to decline without USDA commodity programs.

Third, producers reveal that market crop prices and other non-price factors are the dominant criteria influencing irrigation decisions. For participating irrigators, the dominant

factors affecting year-to-year changes in irrigation were market prices (78%), financial obligations (70%), crop rotations (63%), the farm's irrigation investment (57%), weather conditions (56%), and input-price changes (54%). Program benefits were important for only 20% of participating irrigators. Expected market price is also the dominant factor affecting the commodity program participation decision for both participants (61%) and nonparticipants (52%).

Water supply availability and water costs dominate producer decisions to expand a farm's irrigation capacity (ratings of 83 and 67%, respectively, by participants, and 71 and 65%, respectively, by nonparticipants). For participants, market crop prices, management time, and available credit were also very important in determining farm irrigation capacity (ratings ranged from 55 to 57%). Commodity program benefits were the least important factor in the farm irrigation-capacity decision, for both participants (13%) and nonparticipants (4%). Overall then, producer behavioral judgements indicate that market economic factors contribute the dominant influence in irrigation decisions.

Farm-Tenure/Institutional Constraints Controlling Edwards Aquifer Withdrawals.

Dominant farm-tenure arrangements within the Edwards area, and the withdrawal and aquifer-management responsibilities of the newly established Edwards Aquifer Authority are additional farm/institutional factors ensuring that PFC payments do not encourage new irrigation pumpage through investments in new irrigation wells (USDA, forthcoming 1997). First, characteristics of PFC participants in the study area demonstrate that about 50% of the expected PFC payments go to cash-leased operators. Because the landlord, who is responsible for land investments (which include new or improved irrigation systems, and new irrigation wells), receives no PFC payment in this case, there is no incentive for these payments to be invested in

new irrigation wells (which can approach $100,000). For share-rental farms, the average annual PFC payment is $1,800, with 87% of these farms receiving less than $3,000 and only 12 farms receiving more than $10,000. Landlords receive only about 25 to 33% of the annual payment (averaging $450 to $600). Owner-operator farms in the study area account for only one-third of PFC payments, with 75% of these farms averaging less than $3,000 annually. Only 37 of these farms receive more than $10,000, and of these, 28 are already fully irrigated. Land-tenure arrangements in the study area then, preclude that PFC payments are unlikely to be invested in new irrigation wells, but rather, such payments are more likely to be spent for other farm, nonfarm, or farm-household investment/consumption demand, including water-conservation improvements to existing irrigation systems.

The Edwards Aquifer Authority, formally established on June 28, 1996, requires that all existing users file for a regular water permit based on their historical annual withdrawal. No new wells can be drilled without a permit, and new well permits will be issued only on an "interruptible" basis, that is, users will be allowed to pump from new wells only when such pumpage will not adversely affect spring flows or threatened and endangered species. The EAA is also required to: 1) establish an aquifer management plan within it's first two years; 2) limit total annual pumpage, initially to 450,000 acre feet or less, but after January 1, 2010 to 400,000 acre feet or less; and 3) reduce withdrawals even further if drought conditions create a threat to the springs and to the endangered species. Given that pumpage by existing users already surpasses withdrawal limits, EAA management authorities create sufficient economic uncertainty, making investment in new wells very unlikely. Furthermore, even if PFC payments were invested in a new well, and it was allowed to pump, the EAA would have to

reduce withdrawals by other pumpers to remain within its withdrawal restriction. EAA management authorities then, ensure that the 1996 Farm Act's PFC payment program does not cause additional water withdrawals from the Edwards Aquifer.

The Role of Market Economics in Edwards Irrigation Water-Use/Investment Decisions. PFC payments are a farm income supplement. How farmers allocate these dollars involves economic trade-offs across farm/farm-household and off-farm investments, and across farm-household consumption/savings opportunities that maximize the economic well-being of both the farm and the farm-household. Economic trade-offs ensure that at the margin, irrigation investment decisions are made on the basis of expected market-based economic factors. Producers will not simply allocate PFC payments to irrigation investments. To do so, producers would lose by paying a farm/farm-household opportunity cost, that is, producers would incur the economic loss associated with not using the PFC income for other farm/farm-household consumption/investments that may bear a greater economic benefit.

Conclusions of the Economic Analysis of USDA's Edwards Aquifer BE

The impact of USDA commodity programs under the 1990 Farm Act on the Edwards Aquifer were positive, not negative, meaning that program benefits increased spring flows rather than decreased spring flows. USDA programs then, "may affect, but are not likely to adversely affect" aquifer-dependent species and their habitats. USDA's PFC payment program will not increase pumping from the Edwards Aquifer. Irrigation decisions are made based on market economic conditions and economic principles, while farm-tenure arrangements, a new aquifer-management authority, and new economic uncertainties all ensure that PFC dollars are more likely allocated to increase irrigation efficiency, that is, conserve

Edwards Aquifer water.

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