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ANALYSIS OF WATER RIGHTS PRICES IN NEW MEXICO'S LOWER RIO GRANDE BASIN

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Analysis of Water Right Prices in New Mexico's Lower Rio Grande Basin

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We also thank Dr. F. Lee Brown, professor emeritus of the University of New Mexico. Dr. Brown donated to this project a detailed and comprehensive database on verified groundwater rights prices and consumptive use quantities. That initial database was completed in 2004 and contained detailed data on several variables obtained from the Office of the State Engineer's WATERS database.

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Abstract

The transfer of water rights is an important institution used to stretch available water supplies to meet growing water demands. In the Lower Rio Grande Basin (LRGB), it is used to support sustained population and economic growth. Potential sellers are unsure of what price to charge for water rights, while buyers are unsure of what price to pay. This lack of information on water right prices creates an uncertain and unpredictable market, which jeopardizes the future of water rights to meet growing demands. Improved understanding of the economic forces influencing water rights prices will help buyers and sellers, adding vital information to support continued economic development of the region. Starting in the LRGB, this project has assembled actual verified water rights market data into a database that can be used to characterize the price of water rights. The database includes data from 1980 to 2007. The database and a model were established to explain what factors support a better understanding of the economic and hydrologic forces affecting the demand, supply, and price of water rights.

Many independent variables were considered for the model as predictor for water right prices. The five final variables that were found to be selected as the best predictors were 1) total water consumption by the City of Las Cruces, 2) priority year of the water rights, 3) acre-feet sold, 4) reservoir levels at Elephant Butte, and 5) regional farm income. The model was then used to forecast a baseline forecast based on average recent values of all predictors along with three additional forecasted scenarios for forecasted water right prices for the years 2010- 2020. Additional scenarios included a forecast based on an altered priority (1959) to a more senior priority (1890), a forecast based on an altered quantity of rights offered to the market, a forecast based on altering both the quantity of right and the priority year.

ANALYSIS OF WATER RIGHTS PRICES IN NEW MEXICO'S LOWER RIO GRANDE BASIN

Background

Water is important for New Mexico's agriculture, industry, recreation, and environmental protection. Population continues to grow in the Lower Rio Grande Basin (LRGB)[1] area at a rate of 2% annually (LRGWUO, 2004), and water supplies will not increase to meet those growing demands. Meeting growing water demands in the LRGB has required numerous investments in reclamation along with water marketing, water transfers, urban water conservation programs, and increased reliance on groundwater supplies. Many agricultural producers, industrial users, water utilities, and mutual domestic water user organizations have researched the market value of water rights in the area.

Understanding the factors that affect the basin's scarce supply of water is necessary for managing those waters effectively. The transfer of water rights is an important institution for stretching available water supplies to meet new demands and support sustained population growth and economic activity in the basin. Sellers are typically water rights owners who currently use the water for irrigated agriculture. Buyers are typically cities, industrial parks, or other commercial activities.

One challenge that limits the efficiency of transferring water rights from seller to buyer is that few buyers and sellers have reliable information on the economic value of water rights. Without adequate information, potential sellers are unsure of what price to charge, while buyers are unsure of how the going market price compares to the economic value of the water rights in their proposed use. This lack of information on water rights prices creates an uncertain market, which makes it more difficult to transfer water rights to meet emerging demands. This barrier to water rights transfers to meet growing demand undermines the potential economic productivity of the basin's existing water supplies. Improved understanding of the economic forces influencing water rights prices will inform both buyers and sellers. It will also add essential information to support continued economic development of the region. This information will likely become more valuable in the face of population growth, increased economic activity, emerging environmental values of water, and the potential for climate change.

Water Rights in New Mexico

State law governs the appropriation of water in New Mexico (NM). A private citizen in the state does not own water, but has the right to use water. In the state, a water right is a property right. The nature of a private property right interest under appropriation of water can vary from state to state. A person who diverts water becomes the custodian of the water and may have certain rights and duties with respect to other users and the state. These rights are based on beneficial

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[11]. In the LRGB water plan, the area is geographically defined by the borders of Luna, Sierra, and Otero Counties to the west, north, and east, respectively, and by the State of Texas and the Republic of Mexico to the south. The area also includes a small portion of Sierra County below Caballo Dam and the community of Chaparral in Otero County (LRGWUO, 2004).

use which by the state Constitution is the basis, measure, and the limit of the right to use water in the state[2]. "In New Mexico, the more senior water right holders typically include Native Americans, acequias, and agricultural water users. Junior water right holders typically include municipalities, as well as industrial, residential, and recreational water users" (OSE, 2001).

Water Rights Adjudication

Adjudication is a judicial legal process by which claims of water rights owners are resolved through a court-administered process, the outcomes of which are court-certified titles for the property rights. Adjudication of water rights provides 1) a certainty to water rights owned by individuals or entities, and typically increases the economic value of the water right; 2) a foundation for active water management that enables improved and more efficient watershed planning and management of future water allocations; and 3) a clearly established title to the right to use water (DeMouche, 2004). Adjudication is a legal process conducted through a court to determine the extent of validity of existing water rights. It determines rights to use surface water, groundwater, or both. It creates no new water, but only formalizes under the rule of law existing rights to use it. In New Mexico, an adjudicated water right is one that has been confirmed as valid by the court system.

City of Las Cruces Water Rights

Water resources in the LRGB area are vital for certain water economies to thrive in this area. The agricultural sector supports associated industries, and is itself supported by a low cost of living, availability of land and labor, good year-round climate, and adequate utility systems. The Las Cruces area has also experienced an influx of housing development from new retirees. Over the past several years, Las Cruces has experienced population growth of about 2% per year (City of Las Cruces, 2009). The City of Las Cruces is a major purchaser of water rights in the region, so their current behavior and future plans will influence water right prices. The City is only one of many possible purchasers of water rights. Others include golf courses, industry, and mutual domestics. Still, the scale of their water right purchases in the region merits some discussion of the City's plans.

The City of Las Cruces Utilities Department has positioned itself to obtain water rights to meet its projected water demands. The top dashed line in Figure 1 shows that the City currently has groundwater rights of 42,666 acre-feet. The figure shows projected water demand to the year 2045 in the face of projected demand rates of low, medium, high, and maximum growth. If the City encounters a maximum growth rate, they will have only enough groundwater to the year 2033. The City does not foresee a maximum growth rate, but continues to purchase groundwater rights and perfect the rights they already have based on the maximum growth rate.

In addition, the City has constructed a new water reclamation plant with the capacity to treat up to one million gallons of wastewater per day. Furthermore, the City has started purchasing surface water rights and examining the option of building a surface water treatment plant. This

[2] Beneficial use shall be the basis, the measure and the limit of the right to the use of water (§72-1-2, Water rights; appurtenant to land; priorities). DuMars (1982) stated that the definition for beneficial use "means application of water to a lawful purpose which is useful to the appropriator and the same time is a use consistent with the general public interest in having water utilized to its maximum."

water management planning will allow the City to meet a range of possible projected water demands.

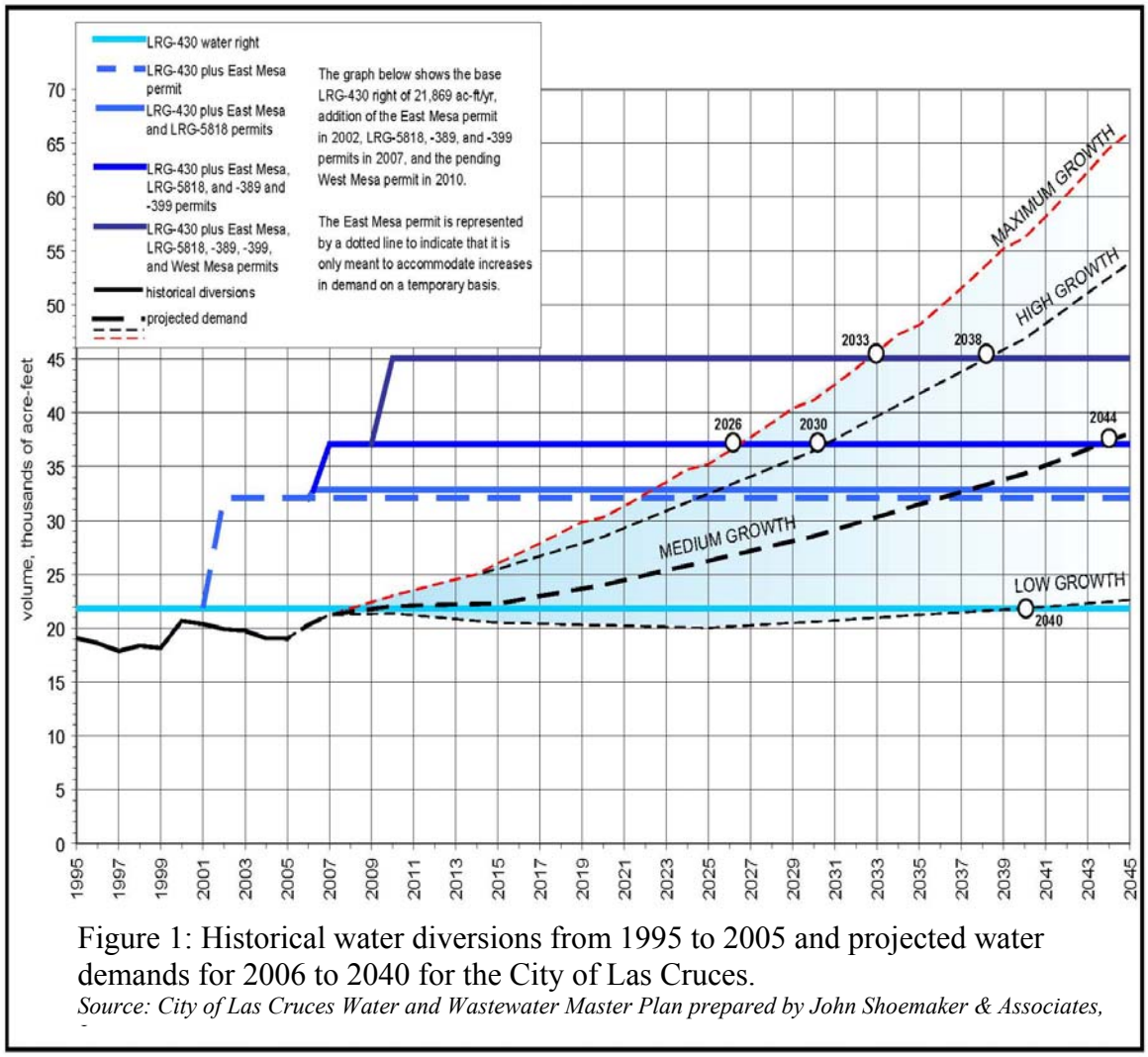

Figure 1: Historical water diversions from 1995 to 2005 and projected water demands for 2006 to 2040 for the City of Las Cruces.
Source: City of Las Cruces Water and Wastewater Master Plan prepared by John Shoemaker & Associates,

The City of Las Cruces is the largest purchaser of groundwater rights from agriculture, and the City currently has an ordinance (LC Ordinance No. 1834) that states a ceiling price ($1,600 per acre-foot) for the purchase of groundwater rights. Other than the City of Las Cruces, there are several other buyer organizations that purchase water rights in the LRGB. These include industry, mutual domestics, and some agriculture.

Need for Water Rights Information

Many agricultural producers and other water rights holders have expressed an interest in securing information to help guide their decisions on the timing, quantity, and price of water rights they trade. Water rights cannot be appraised as easily as a piece of land. Moreover, many appraisers

in the region do not separate water rights from land values (Trego, 2009). A growing scarcity of water has been reflected by rising water rights prices that have been observed since the early 1980s. Groundwater rights can be traded if the old and new uses are located in the same groundwater basin. Any new changes in demand or reduction in supply within the basin can increase the price of water rights (Hutton et al., 2004). With the increasing demand for water for municipal, industrial, and environmental uses, the transfer of water rights has the potential to economically benefit both parties to the trade. Since water is so important to the basin's sustained economic development, it is essential to learn more about the quantitative factors that contribute to the price of water rights.

New Mexico is a prior appropriation state. In the face of drought, competing demands, and diminishing resources, good planning is crucial. Priority administration and beneficial use provide the basis for New Mexico's water distribution. The state's surface water supply and most of the groundwater supply are fully or over appropriated. If all the water rights permits, licenses, and declarations were fully exercised today, current supply would not likely meet demand. Voluntary agreements among water users such as shortage sharing, rotation, water banking, or other forms of voluntary agreements are encouraged by the State Engineer. Priority administration is the tool used by the State Engineer for water rights administration within the state in times of drought. If there is a priority call on the river due to drought, the holders of more junior water rights will be less favored than those holders with more senior water right.

Many studies between 1987 and 2005 revealed a dramatic difference in the value of water in urban uses versus agricultural uses (Brewer et al., 2008). These studies showed that the average price for water transferred from agriculture to a municipality was $4,366 for one acre-foot of water annually, while the transfer price of water within agriculture showed a value of $1,747 per acre-foot per year.[3] Griffin and Boadu (1992) noted that the mean estimated net gain from the transfer of water in Texas was $10,000 per acre-foot. Other studies estimate that the marginal value of water in municipal and industrial uses is three to four times its marginal value in agricultural uses (Carey and Sunding, 2001).

Objectives

This study has six objectives associated with improving information on the economic value of groundwater rights in the Lower Rio Grande Basin of New Mexico. These include:

- Verify the transactions of an existing database[4] on prices and consumptive use of water rights traded in New Mexico's LRGB area.
- Secure, update, and verify data on water rights transactions from 2004 to 2007.
- Conduct a survey to identify prices of water rights traded in New Mexico's Lower Rio Grande Basin.
- Assemble data that could be potential predictors of water rights prices in the LRGB.

[3]An acre-foot of water is enough water to cover an acre of land with one foot of water and is about 325,900 gallons.
[4]Database acquired from Dr. F. Lee Brown, which contained information from 1976-2004 on water right transactions.

- Formulate an econometric model that explains water rights prices.
- Use the model to forecast water rights prices for selected future years.

The data collected for this analysis were used to help meet these objectives. The data were applied only to groundwater rights traded. Surface water rights were not used in this study for two reasons. First, we were updating an already established dataset that contained only groundwater rights data. Second, we were gathering information from the Office of the State Engineer (OSE) New Mexico Water Rights Reporting System database, which is currently limited to groundwater activity only. The OSE hopes in the future to provide transaction information for surface water. Some data on surface water rights prices are available for the basin, but these currently are held privately and were unattainable to our research team.

Approach

The study objectives were met by developing a database of historical groundwater rights transactions along with factors likely to influence those prices. After this database was assembled, a model was developed with the intent of explaining the price of water rights associated with factors that affect either the supply or demand of water rights.

Verification of Existing Database

An existing database on water rights prices was secured and was augmented with more recent trading activities from 2004 - 2007. Variables included sale and transaction dates, seller and buyer names, OSE water right file numbers, diversion amount, price per acre-foot, total price of the transaction, and the priority year of the water right. The database contained 74 total transactions, of which sales price information was available for 24. These transactions were for water purchases only; no transactions associated with land purchases were included in the database. Information was acquired through the OSE WATERS database, a web-based interactive reporting system for groundwater rights. It is used, housed, and supported by the OSE (OSE, 2009). Information retrieved from the WATERS database is described in Table 1.

Table 1: List and description of variables collected from the OSE Waters database

Variable Name	**Description**
Seller	Seller of the groundwater rights.
Buyer	Purchaser of the groundwater rights.
Sale Date	Date on the bill of sale (when no information is available, either the buyer or seller provides the date).
Water Rights File Number	Identifier assigned to each water rights file.
Consumptive use per year	Amount of water consumed and not returned to the river as return flow.
Price per acre-foot	Price per acre-foot consumed.
Total value of the sale	Price paid per acre-foot multiplied by the amount of acre-feet traded measured in consumptive use.

The WATERS database was established to store and present information regarding water rights and to maintain electronic records of related paper files, housed in the WATERS system. The Office of the State Engineer maintains these files in one location and provides web access to the

information. Using WATERS, anyone can obtain information concerning water use as well as data on water rights, location of rights, owners of rights, and historical details of a well and its construction. Occasionally, the WATERS database does list the price per acre-foot. Where this information was lacking our team contacted either the buyer or seller in the transaction.

Securing Additional Data

To update the established database, a query was requested and conducted by OSE to identify water rights for which there had been a recent change in status, that is, change of ownership or change of diversion. From these queries, file numbers were examined using the WATERS database to see if a sales transaction had occurred. The OSE query contained 49 groundwater rights transactions between the years 1986 and 2007. Once the database was updated, a survey process was initiated.

Survey

An introductory letter (Appendix A) and a conversation script (Appendix B) were developed and approved by NMSU's Institutional Review Board. The introductory letter, which described the research efforts, research team, and purpose, was used as an initial contact, paving the way for a follow-up call. The conversation script was used to verify information from the WATERS database and to acquire price information for the water rights transaction.

Using contact information from the database, individuals who were a party to a groundwater rights transfer sometime during the years 1986 to 2007 were sent the introductory letter. Subjects (before and after) were contacted by telephone within two weeks to the extent possible. Using the conversation script, subjects were asked if they were willing to participate in the research and then asked to verify or confirm the information details (Table 1) from their recent water rights transaction. After a review of information, subjects were then asked about the purchase price of the transaction and any additional transaction fees, such as lawyer fees, title fees, and OSE fees.

Data Assembly for Water Rights Price Predictors

Several variables were examined and selected as potential independent predictor variables, because supply and demand factors can determine a water right's market price, and the predictor variables were chosen based on how well they explained price through impacts on either supply or demand (Table 2).

Table 2: Candidate predictors of water right prices

Supply	**Demand**
Energy	Population
Climate	Income
Reservoir level	Grass sod
Farm income	Xeriscape
Acre-feet sold	Priority date
	Number of utility hook-ups
	Environmental value index
	Water consumption
	Consumer price index (CPI)

For the supply predictors:

- *Energy* – The price of oil per barrel was used as a predictor for energy and measured as the annual average crude oil price, adjusted for inflation to 2007 (InflationData.com, 2010). This information represents the cost of energy, the most important input affecting the cost of pumping. Most subjects stated that the cost of pumping was a determining factor for selling their water rights. That is, as the cost of pumping water increases, the economic value of pumped water may fall.
- *Climate* – Annual precipitation for Doña Ana County was used as a climate predictor. The data were gathered from the Western Regional Climate Center (Western Regional Climate Center, 2010) using the USDA-ARS Jornada Experimental Range weather station. Precipitation may affect supply by adding to the supply of water. However, it may also affect demand; if precipitation increases in a given year, that year's demand for pumped water will fall, since precipitation is a good substitute for pumped water.
- *Reservoir level* - This variable includes data collected from the U.S. Bureau of Reclamation (BOR*)* streamflow gauge at the Elephant Butte Dam (U.S. Bureau of Reclamation, 2009). The BOR field office in El Paso, TX, monitors Rio Grande Project reservoir levels. The BOR uses a water-stage recorder to document the daily reservoir level. Annual average reservoir levels were derived and used in the dataset. Reservoir levels affect supply as a substitute for the supply of water.
- *Regional farm income* – Farm income data for the complete study period were not available. Therefore, this study used data on cash receipts as a proxy for farm income (National Agricultural Statistics Service, 2008). Farm income was expected to affect water rights supplied by irrigators because as farm income falls due to lower prices, lower yields, or rising costs, the opportunity cost to continue using groundwater for irrigated agriculture also decreases, compared to the alternative of selling the groundwater right.
- *Acre-feet sold* – This variable represents the total number of water rights sold (without land) in the Lower Rio Grande Basin associated with each transaction. A greater number of acre-feet sold was expected to cause a lower price.

For demand predictors:

- *Population* – The Doña Ana County estimated population for the coinciding year (U.S. Census Bureau, 2009) was used as the population predictor. If population increases, then the demand for water rights is expected to increase due to the increase in municipal water use.
- *Income* – The Doña Ana county per capita income (Bureau of Business and Economic Research, 2009) was used to predict groundwater rights prices. As income increases, there is the motivation to spend more on water-related products (e.g., appliances and landscapes), which raises the demand for water used in urban homes.
- *Grass sod* - Price of purchasing sod is measured by the price per square foot. Data for the price of sod were collected from Engineering News-Record (ENR.com, 2009), a subscription website used by the construction industry. The variable for the price of sod is based on home or business owners installing a new lawn and does not reflect the continued operation and maintenance of a lawn. An increase in the price of sod would decrease demand for sod, and smaller lawn areas would reduce the demand for water.

- *Xeriscape* – Xeriscape a water conserving landscape alternative to irrigating lawns and may include various combinations of desert plants and gravel. Data for the price of xeriscape per square foot were collected from Engineering News - Record (ENR.com, 2009) available on the same subscription website as grass sod prices.
- *Priority date* - This is the date water was first put to beneficial use, as determined by the OSE. Priority date may be a good predictor of demand. Under the prior appropriation doctrine, people with older more senior water rights will receive their water before those with newer more junior water rights. "Prior appropriation doctrine has the following key features: requirement for beneficial use; first in time, first in right; vested water rights that become a property interest; and use it or lose it" (DeMouche, 2004). This is important to buyers because if a priority call is made on the river, persons with junior water rights dates have a greater risk of not receiving water for that irrigation season. People may therefore look to purchase rights with earlier priority dates.
- *Number of utility hook-ups* – This is the number of households and commercial entities that are serviced by the City of Las Cruces Utilities Department. If the number of hook-ups increases, demand for water increases, which will affect the demand for water rights in the region. This information was provided by City of Las Cruces Utilities Department.
- *Environmental value of water* –With the rising environmental ethic in the United States (US), there has been an increased water demand for environmental uses (e.g., endangered species flows). This environmental ethic has also resulted in some homeowners embracing water conservation in various forms. Changes in the environmental value of water over time are difficult to measure. Nevertheless, the changing size of the U.S. Environment Protection Agency (EPA) budget could be one proxy that reflects national trends in the environmental value of water (U.S. Government Printing Office, 2009).
- *Water consumption* – Annual total consumption of water by the City of Las Cruces. Wells belonging to the city are metered, and data were provided by the City of Las Cruces Utilities Department and are shown as the amount of water (in gallons) consumed annually.
- *Consumer price index (CPI)* - The U.S. consumer price index for the years 1985-2008, was used to convert to inflation-adjusted terms (Financial Trend Forecaster, 2009).

Econometric Model

An econometric model specifies the statistical relationship that is believed to hold among the various economic quantities pertaining to a particular economic observable process under study.

A linear econometric model was estimated to explain the quantitative importance of each predictor independent variable in explaining the price of a water right. The model involves multiplying parameters to be estimated by independent variables. The best estimated values of these parameters are obtained by least-squares fitting of the model to the data. The same parameters were then used to forecast the future value of water right prices based on projected values of each predictor independent variable for the years 2010-2020.

Water rights price per acre-foot was used as the dependent variable. Analysis of that price provided a mechanism to explain factors that influence the trading price of water rights and to forecast its future value.

Model Specification
The model explaining the price of a water right is specified as:

$$(1)\ Y_i: \quad \beta_0 + \sum_j \beta_j X_{ij} + e_i$$

Where:

Y_i = Water rights price, dependent variable, in dollars per acre-foot.

β_0 = intercept

β_j = parameter for *j-th* explanatory variable

X_{ij} = *i-th* of 39 observations on *j-th* of 5 explanatory variables shown in Table 1.

e_i = error term for *i-th* observation, i.e., the deviation of the actual and predicted value of the *i-th* observation on water rights price.

The parameters of the model are determined by fitting them to the data to minimize the sum of squared residuals between the observed and predicted water right prices. If the observed water rights price for the *i-th* observation is denoted by Y_i, the best fit of the model to the set of observations is carried out by minimizing the sum of the squares of the errors between the observed and model-predicted values. This process produces the estimates for the parameters, β_j.

Many independent variables were considered as candidates to predict water rights prices. Since it was not known in advance which variables would be good predictors, a considerable amount of time was invested in securing data on variables that after statistical analysis proved to be weak predictors. Those weak predictors are shown in Appendix C.

Experimentation was required to find statistically acceptable independent variables that were proven to be good predictors of water rights prices. There were several criteria used to select the variables. They included t statistics, expected algebraic sign of the parameter, and percentage of variance explained by the independent variables. The five final variables that were found to be selected as the best predictors are shown in Table 3.[5]

[5] The estimated predictor is a single-equation model. In it there was a single dependent variable Y and five explanatory variables. The single equation model estimated the expected value of Y conditional upon the fixed values of the explanatory variables. This presumes a cause and effect relationship solely from the X's to the Y. However, it was possible that water rights prices and quantities are determined simultaneously. That is both price and quantity could be simultaneously determined by factors affecting both supply and demand. The price received could fall with increased quantity offered to the market. Yet, the quantity offered to the market could increase as the price increased. This is a difficult challenge, so we tested a preliminary model to see if quantity sold was an empirical function of historical price. A simultaneous equation approach (three stage least squares) was conducted, in which results showed that price had no significant predictive power to explain quantity sold. Why not? Contacts to water rights traders from our survey work showed that quantity made available to the market came mostly from

Table 3: Variables used to explain the price of water rights in the Lower Rio Grande Basin, New Mexico

Dependent Variable	**Identifier**	**Units**
Price of a water rights	PRICE	Dollars per acre-foot
Explanatory Variables		
Total water consumption by City of Las Cruces	LCU	1,000s acre-feet per year
Priority year of the water rights	PRIORITY	Calendar year
Acre-feet Sold	AFS	Quantity sold in acre-feet
Reservoir level	RL	Annual average reservoir level at Elephant Butte (1000's acre-feet)
Regional farm income	CCR	Cash receipts for crops; Doña Ana & Sierra counties (millions of dollars)

Model Estimation

Ordinary least squares (OLS) regression was used to estimate the model with residuals tested for non-constant error variance using the White test. This is a common statistic calculated to test for a constant variance in the error term. Preliminary results showed that constant variance of the residuals could not be rejected.

A test for multicollinearity was performed. Reservoir levels and regional farm income were found to be somewhat correlated. We adopted Klein's test rule of thumb, which suggests that multicollinearity may be a problem only if the R^2 obtained from the regression is greater than the overall R^2. Further analysis was conducted on the model using a variance inflation factor (VIF). The VIF is useful in determining which if any variables are sufficiently collinear to cause a problem in predicting water right prices. Generally, if the VIF of a variable exceeds 10, that variable is said to be highly collinear. After completing a VIF test (Table 6) none of the variables have a VIF value larger than 10. Therefore, the overall regression model doesn't reveal significant collinearity.

Forecasting Water Rights Prices

After estimating the water rights predictor, the estimated model was used to forecast the future price of a water right in the LRGB for the years 2010-2020. For this study, projected values of the predictor variables described above were applied to the model. The application of estimated parameters to projected values of the independent variables for the years 2010-2020 produces the forecast selling price of a water right. Projected values of water consumption by the City of Las Cruces were secured from the City's published 40 year water plan (City of Las Cruces, 2008).

Projections in the plan were developed for water conservation and without water conservation policies. For forecasting purposes we used the average of the two. The projections made in the plan for years 2008-2010 were rather high compared to the actual city consumption for those

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rights inherited from others. The amount inherited determined the amount offered to the market, not the anticipated price received. So a single equation model in which price is a one-directional function of quantity is supported by the facts.

years. For that reason, the average was used for two situations; one with a water conservation policy in the city and one without such a policy. Projections for priority year, regional farm cash receipts, acre-feet sold, and reservoir level were calculated by averaging all trades between the years 2003-2007; producing a five year average. Projections of all remaining water rights predictors were based on observed average values for recent years (2003-2007), adjusted for alternative scenarios described in more detail below.

Results

Water Right Prices Explained

Table 4 summarizes the water rights prices and their predictors. The table provides insight into the relationship between the estimated parameters and the data collected from 1986-2007. The dependent variable, price of a water right, ranges from a minimum of $490 to $4,153 has a standard deviation of $734. The wide range of observed data may indicate that buyers or sellers have a wide range of expectations on the price to charge or pay when entering the market for water rights.

Consumptive use by the City of Las Cruces had a mean of 17.85 with a standard deviation of 1.40. This finding indicates a modest but sustained rate of growth over time for water consumption in the City. The modest rate indicates that the City's population continues to grow, but per capita water usage is declining. The table shows that the water right's priority year had a 1959 average seniority date with a small standard deviation of 9.05 years. The quantity of water rights sold in the market had a mean of $107.33 with a standard deviation of $161.18. Some years have high sales and some show much lower market activity. The table also shows that reservoir levels had an average water level of just over 1 million acre-feet of storage in Elephant Butte Reservoir, while regional farm income had an average of $190 million of cash receipts over our period of record.

Table 4: Summary statistics of water rights prices and their predictors, Lower Rio Grande Basin, New Mexico

Dependent Variable	**Mean**	**Standard deviation**	**Min**	**Max**
Price of a water right (dollars per acre-foot)	2,128.65	734.26	490.20	4,153.56
Explanatory Variables				
Total consumption by City of Las Cruces	17.85	1.40	14.57	19.71
Priority year of water right	1959	9.05	1944	1979
Regional farm income (in millions of dollars/year)	190.30	21.73	148.36	22789
Reservoir Level	1041.06	710.14	179.99	2096.30
Acre-feet sold	107.33	161.18	2.00	792.00

Table 5 shows the results of the water right price predictor equation. It includes the estimated parameters and associated statistics for each predictor of water rights prices. The table includes parameter estimates, standard errors of the estimates, *t*- statistics, probability of a zero parameter for each parameter, and the Variance Inflation Factor (VIF) results of a preliminary test for collinearity.

The equation that best explains the price of a water right is:

$$(2)\ Price:\ 23{,}708 + 95.80\ Total\ Consumption\ by\ City\ of\ Las\ Cruces - 12.83\ Priority\ year\ of\ water\ right + 11.42\ Regional\ Farm\ Income - 1.21\ Acre feet\ sold - 0.22\ Elephant\ Butte\ Reservoir\ Level$$

Table 5: Results of regression model predicting the price of a water right in the Lower Rio Grande Basin

Explanatory Variable	**Parameter Estimate**	**Standard Error**	**t-Value**	**Prob > |T|**	**VIF**
Intercept	23,708	21641	1.01	0.28	0
Total water consumption by City of Las Cruces	95.80	79.66	1.20	0.23	1.36
Priority year of the water right	-12.83	10.89	-1.18	0.24	1.07
Farm income	11.42	5.84	1.95	0.05	1.77
Acre-feet sold	-1.21	0.60	-2.01	0.05	1.03
Reservoir Level	-0.22	0.20	-1.09	0.28	2.19
$R^2 = 0.45$	F value = 5.48	Pr > F < 0.01			

Each coefficient has an important interpretation. If total consumption of water by the City of Las Cruces goes up by 1,000 acre-feet per year, the price of an acre-foot of water right will go up by an estimated $95.80.

A more junior water right with a later water right priority year results in a reduced water right price. The price per acre-foot of a water right falls by $12.83 for each year more junior the water right is assigned. The negative coefficient (-12.83) met prior expectations because the greater potential for a priority call on the river in drought conditions means that a more senior water right should have a greater market value.

Regional farm income is also a good predictor of water right prices. An increase in farm income (cash receipts) of one million dollars per year causes the price per acre-foot of water right to increase by $11.42. As farm income goes up, irrigators incur a greater loss in farm income from offering for sale a water right.

The impact of acre-feet (quantity) offered for sale to the market was negative, which was also expected. This finding means that as one additional acre-foot is offered for sale as part of a transaction, the price of a water right will decrease by $1.21. Higher quantities offered for sale reduce the price needed to clear the market.

The level of water in the local reservoir (Elephant Butte reservoir) also came in as a predictor for water right prices. Its negative sign indicates substitution between surface water and groundwater. As the annual average water level per rises in the Elephant Butte reservoir by 1000 acre-feet, the price (value) of a ground water right falls by $0.22. This occurs because surface water is more readily available compared to the competing groundwater.

Water Rights Prices Forecasted

Tables 6 – 9 presents four scenarios for forecasted water right prices for the years 2010-2020. These scenarios include:

- A baseline forecast based on average recent values of all predictors
- A forecast based on an altered priority (1959) to a more senior priority (1890)
- A forecast based on an altered quantity of rights offered to the market from the recent historical average (99 acre-feet per year) to a larger amount (500 acre-feet per year)
- A forecast based on altering both the quantity of rights to the higher level (500) and the priority to the more senior year (1890)

With the exception of the City of Las Cruces water use, the baseline forecast shown in Table 6 is based on the average recent values of all predictors. The City's projections were taken from its 40-year water plan. The table shows a forecast water right price through years 2010-2020 that gradually increases from year to year. Increases between any two years range from a low of about $50 to a high of about $200. Growing demands by the City of Las Cruces exert a steady upward pressure on the region's water right prices. Pumping larger quantities of water to support a growing population can be done. But the forecast shows that serving their needs against a background of hydrologically and legally limited supplies is expected to bring about a higher price for traded water rights. According to our results, this higher price brought about by rising demands by the City is associated with water being transferred from irrigated agriculture to urban uses.

Table 6: Forecast water rights price for the Lower Rio Grande Basin, New Mexico, 2010-2020, based on recent historical average values of predictors.

Year	**Price**	**LC Water consumption**	**Priority year**	**Regional farm income**	**Acre-feet sold**	**EB Reservoir level**
	Forecast	**Projections**				
2010	$2,964	24.2	1959	200	99	429
2011	$3,015	24.8	1959	200	99	429
2012	$3,065	25.3	1959	200	99	429
2013	$3,095	25.6	1959	200	99	429
2014	$3,116	25.8	1959	200	99	429
2015	$3,146	26.1	1959	200	99	429
2016	$3,166	26.3	1959	200	99	429
2017	$3,297	27.7	1959	200	99	429
2018	$3,368	28.5	1959	200	99	429
2019	$3,469	29.5	1959	200	99	429
2020	$3,519	30.0	1959	200	99	429

Information shown in Table 6 is used as a comparison for the other three scenarios. While the projections of priority year and quantity of acre-feet sold change from one scenario to the next, all four tables show growing demand by the City of Las Cruces.

Table 7 shows results for scenario two. In this scenario, forecast water right prices are presented for the case of very senior water rights offered to the market for the period 2010-2020. Compared to Table 6, all values of predictors other than priority year are unchanged. Table 7 shows a noticeable impact on water right prices that results from a more senior water right offered for sale. Water rights owners in the LRGB who own a right with 1890 seniority are forecast to receive a higher price for their water rights than those with more junior rights.[6]

The increase in price of water rights is about $900 for each year forecasted, equal to the coefficient of $12.83 in the regression equation multiplied by 69 years higher priority. The perceived potential for the risk of a priority call in drought raises the market value of the more senior water right.

Table 7: Forecast water rights price for the Lower Rio Grande Basin, New Mexico, 2010-2020, based on a priority date of 1890.

Year	Price	LC Water consumption	Priority year	Regional farm income	Acre-feet sold	EB Reservoir level
	Forecast	Projections				
2010	$3,850	24.2	1890	200	99	429
2011	$3,900	24.8	1890	200	99	429
2012	$3,951	25.3	1890	200	99	429
2013	$3,981	25.6	1890	200	99	429
2014	$4,001	25.8	1890	200	99	429
2015	$4,031	26.1	1890	200	99	429
2016	$4,052	26.3	1890	200	99	429
2017	$4,183	27.7	1890	200	99	429
2018	$4,254	28.5	1890	200	99	429
2019	$4,354	29.5	1890	200	99	429
2020	$4,405	30.0	1890	200	99	429

Table 8, scenario three presents a water right price forecast when the quantity of traded water rights offered to the market increases compared to the quantity showed in Table 6. In Table 8, the average quantity of water rights sold increased from the historical average of 99 acre-feet to the much large 500 acre-feet for each year in the forecast period. The price impact of increasing the quantity of water rights in the market reduces the forecast price considerably every year of the forecast period. In fact, the higher quantity offered to the market reduces price by an average of just under $500 for every year forecasted. The impact on price associated with the higher quantity offered to the market comes from multiplying the regression coefficient $1.21 by the difference in quantity offered (500 – 99). A clear message emerging from our study is that any water right seller should guard against offering too much for sale in any one given year. If a very

[6] For example, New Mexico State University owns a considerable amount of water rights that may have very senior status.

large quantity of water rights is made available for sale, the price will fall considerably, as shown by comparing Table 6 and Table 8.

Table 8: Forecast water rights price for the Lower Rio Grande Basin, New Mexico, 2010-2020, based on a quantity offered to the market of 500 acre-feet.

Year	Price	LC Water consumption	Priority year	Regional farm income	Acre-feet sold	EB Reservoir level
	Forecast	Projections				
2010	$2,480	24.2	1959	200	500	429
2011	$2,531	24.8	1959	200	500	429
2012	$2,581	25.3	1959	200	500	429
2013	$2,612	25.6	1959	200	500	429
2014	$2,632	25.8	1959	200	500	429
2015	$2,662	26.1	1959	200	500	429
2016	$2,682	26.3	1959	200	500	429
2017	$2,813	27.7	1959	200	500	429
2018	$2,884	28.5	1959	200	500	429
2019	$2,985	29.5	1959	200	500	429
2020	$3,035	30.0	1959	200	500	429

Table 9 presents the water right price forecast for scenario four. It shows the impact of price on water rights with two price predictors changing at the same time. First, a more senior water right priority date (from 1959 to 1890) is offered for sale. In addition, an increase in acre-feet is offered to the market (from 99 to 500 acre-feet). Projecting these two variables together shows the joint impact on price resulting from impacts of both predictors. When compared to the baseline forecast in Table 6, the price of water rights is increased by about $400 for each year forecasted. The Table 6 results are based on the estimated regression equation coefficients shown in Table 5. A higher priority year raises the price by $12.83 for each additional year of the right's seniority. Additional water rights placed in the market reduces the price by $1.21 per acre-foot. In this scenario there are several market mechanisms competing to determine the price of water rights. While the higher priority year exerts upward pressure on the price, the larger quantity of water rights placed on the market reduces that upward pressure.

Scenario four presents a good example of how buyers or sellers of water rights can use the price predictor. Readers of this report can apply water right information for a water right in which they have an interest. Table 9 shows impacts on forecast water right prices when two predictors both change. Similarly, readers could likely use this report's results to forecast a future price for several different variables that are different from the ones presented in this report.

Table 9: Forecast water rights price for the Lower Rio Grande Basin, New Mexico, 2010-2020, based on a 1890 priority and a quantity offered to the market of 500 acre-feet.

Year	Price	LC Water consumption	Priority year	Regional farm income	Acre-feet sold	EB Reservoir level
	Forecast	Projections				
2010	$3,366	24.2	1890	200	500	429
2011	$3,416	24.8	1890	200	500	429
2012	$3,467	25.3	1890	200	500	429
2013	$3,497	25.6	1890	200	500	429
2014	$3,517	25.8	1890	200	500	429
2015	$3,548	26.1	1890	200	500	429
2016	$3,568	26.3	1890	200	500	429
2017	$3,699	27.7	1890	200	500	429
2018	$3,770	28.5	1890	200	500	429
2019	$3,871	29.5	1890	200	500	429
2020	$3,921	30.0	1890	200	500	429

Table 10 contrasts results shown in Tables 6-9 in a compact way. It summarizes forecast price associated with all four scenarios described above. While this table presents no new information, it presents a side-by-side contrast of price impacts unique to each of the four scenarios. Scenario 2 shows the highest forecast price. Scenario 4 has the second highest. Scenario 1 is the third highest. The lowest forecast occurs under Scenario 3.

Table 10: Forecast water rights price for the Lower Rio Grande Basin, New Mexico, 2010-2020, compared under four scenarios.

Year	Price impacts			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
2010	$2,964	$3,850	$2,480	$3,366
2011	$3,015	$3,900	$2,531	$3,416
2012	$3,065	$3,951	$2,581	$3,467
2013	$3,095	$3,981	$2,612	$3,497
2014	$3,116	$4,001	$2,632	$3,517
2015	$3,146	$4,031	$2,662	$3,548
2016	$3,166	$4,052	$2,682	$3,568
2017	$3,297	$4,183	$2,813	$3,699
2918	$3,368	$4,254	$2,884	$3,770
2019	$3,469	$4,354	$2,985	$3,871
2020	$3,519	$4,405	$3,035	$3,921

Scope and Limits

This report identifies the most important predictors of water rights prices in the Lower Rio Grande of New Mexico. It also presents forecasts of those prices for the years 2010-2020. However, a forecast is not a fact. Caution is advised on the use of the forecast price of water

rights presented in this report. Many factors influence water rights prices that were not explained by the historical facts assembled by our team. The forecasts shown in Tables 6-9 apply the model's estimated parameters shown in Table 5 to projected values of its predictors. None of these predictors have yet been observed. So the forecast water rights price shown in Tables 6-9 can be expected to deviate from water right prices that actually emerge in future years. Forecast water rights prices in more distant future years will likely be a greater but unknown distance from actual prices that emerge in those years. The model was built using historical factual data. While the data will not likely be repeated in future years, forecasts in this report are based on the expectation that the structural relationship between price predictors and prices will be unchanged.

Readers of this report can use the estimated model presented in Table 5 to secure a forecast of an individual water right's value. This forecast can be secured by experimenting with a range of values of the predictors different than those shown in Tables 6-9. Readers can insert the priority year of the water right for which they have an interest if they wish to estimate a market-trading price of the water right for one or more future years. However, it should be cautioned that only about half of the variation in historically observed water rights price was explained by the five predictors presented in Table 5. Doubtless, numerous other economic, hydrologic, meteorological, legal, cultural, and institutional factors are at work influencing water right prices.

Conclusions

Informed management of water resources is important to a growing and water-dependent economy. The southern New Mexico economy relies on flows from the LRGB and is strongly dependent on a reliable water supply for all demands. These demands include irrigation, urban, and environmental uses of water. The stream adjudication process continues. That process will continue to be important to New Mexico. Completion of the adjudications will clarify water rights that are available, making the management of these resources more informed. The completed adjudication will very likely affect the market value of future water rights.

Information involving future water right prices can inform urban and agricultural water planners. For example, if a farmer has knowledge regarding future water right prices, then a more informed decision can be made on selecting crops, and crop inputs like land, water, and irrigation technology. Important choices face actual and potential holders of water rights on whether or not to enter the market either as a buyer or seller.

Information on factors that cause significant variation in a water right's price can help inform economic planners when making important decisions. These factors can be used to help secure a better understanding of the present and future price of water rights. This improved understanding can educate water right buyers, sellers, and other stakeholders. A stable market along with adjudication can inform water resources management and future planning that evaluates impacts of growth of the region's water economy.

Trends in population growth, economic activity, and climate change all contribute to the market value of a water right. Results of this study show that priority year of the water right, total water consumption of Las Cruces, regional farm cash receipts, acre-feet sold, and Elephant Butte reservoir levels all have a significant impact on the price of a water right in New Mexico's Lower Rio Grande Basin.

The analysis described in this report has several limits, all of which point to the need for continued work. This analysis was limited to trades of groundwater rights, due to a lack of accessible data on the price of surface water rights. Surface and groundwater are hydrologically connected and should be analyzed together where possible. It is unlikely that there will be new water supplies to support development of new water rights.

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Appendices

Appendix A: Sample Letter

Mr. XXXXXX
Vice President of YYYY
El Paso, TX 79930-2634

Dear Mr. XXXX:

I am a Graduate Research Assistant at New Mexico State University in the College of Agricultural, Consumer and Environmental Sciences. I am working on a research project for my thesis entitled "Planning for a Database of New Mexico Water Rights Prices". The main goal of this project is to construct a historical series of prices paid for water rights in the Lower Rio Grande basin.

With continued drought conditions in New Mexico combined with sustained population growth, economic growth, and environmental restrictions on water use have all increased demand for water. New Mexico's water supplies are less able to stretch to the point of meeting its water demands. The price of water and water rights has a major influence on its use, on the wealth of water right owners, on the affordability of its transfer to new users, and on the state's future economic development. The benefit of this research will assist water planners to first identify the expected availability of water and the price at which that available water will be provided to the optimal consumers and second address the equality of the market mechanism.

I have reviewed the WATERS database on the Office of the State Engineer website (a public domain) and have found documents reporting that XXXXX Industries recently sold their water rights (Lower Rio Grande File #LRG-7XXX) and that you are now the owner of those water rights. I am writing to request your assistance in ascertaining the price paid for the acquired water rights and to verify that the information below is correct:

1. Consumptive Use was 3 acre-feet per year.
2. Diversion amount was 3 acre-feet per year.
3. Purpose of use has changed from Domestic use to other.

You will experience no foreseeable risks or discomfort from this survey because the information collected will be confidential and presented in summary form. Participation is optional however the telephone interview will take no longer than 15 minutes.

I will contact you approximately one week from the date you receive this letter. The telephone contact information I have listed for you is 915-5XX-XXXX.

If this information is not correct or you wish not to participate in the study please contact Leeann DeMouche by e-mail ldemouch@nmsu.edu or phone (575)646-3973. If you have any questions regarding your right as a research subject you may contact the VP of Research office at (575)646-7177. Thank you for your time and participation in this study.

Sincerely Yours,

Shawn Landfair

Appendix B: Script

Hello, I'm _____ from New Mexico State University, College of Agricultural, Consumer, and Environmental Sciences.

Recently, I sent you a letter from me explaining the water rights database research I am conducting at NMSU

As stated in the letter, information collected from you will assist in the development of an economic analysis of water rights in the Lower Rio Grande Basin.

You will experience no foreseeable risks or discomfort from this discussion and all information we obtain from you will be kept confidential. This telephone interview will take no longer then 15 minutes. Do you presently have time to participate in the discussion or could you give us a date, time, and phone number where we could reach you at a more appropriate time. If you should decide not to participate or to withdraw from the interview at anytime, there will be no penalty or loss of benefit to you.

Thank you for participating in my research. I would like to discuss with you the water rights transaction between you and (name) on (date). To the best of your knowledge, what was the price that you paid per acre-foot of water? What was the diversion amount? What was the consumptive use? Did the purpose of use change? If so, what did it change to?

If you have any further questions or concerns regarding this research project please contact my research advisor Dr. Frank Ward at 646-1220.

If you have any questions regarding your right as a research subject you may contact the VP of Research at 646-7177. Thank you for your time.

Appendix C: Statistical summary of rejected parameters

Rejected parameters	**Mean**	**Max**	**Min**
Energy	34.42	66.66	15.73
Climate	9.77	16.61	4.50
EPA	39.19	50	30
Income	22.99	2.07	20.26
Grass sod	22	25	20
Xeriscape	13	18	11
Residential hook-ups	19,491	25,849	13,752
Commercial hook-ups	1702	1988	1455
Population	176.87	198.04	153.04
CPI	176	201	110