Trends in water market activity and price in the western United States

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Received 12 April 2005; revised 5 May 2006; accepted 7 June 2006; published 8 September 2006.

[1] Over 2000 water market transactions that occurred in the western United States from 1990 to 2003 were examined to learn who sold to whom and for what purpose, how much water was involved, and how much it sold for. The transactions show that much more water changes hands via leases than via sales of water rights. Public agencies and irrigators are the most common lessors, with lessees being fairly evenly distributed across types of buyers. However, with water rights sales, irrigators are by far the most common sellers and municipalities the most common buyers. Across the West in general, the number of leases has been rising in recent years, as have their prices. The prices of water right sales have also been rising, but the number of sales has not. The price of water is highly variable both within and between western states, reflecting the localized nature of the factors that affect water prices.

Citation: Brown, T. C. (2006), Trends in water market activity and price in the western United States, *Water Resour. Res.*, *42*, W09402, doi:10.1029/2005WR004180.

1. Introduction

[2] Water in the western United States has become scarcer as population, economic growth, and changing values have increased demand for water [*Gillilan and Brown*, 1997]. Where institutions allowed it and transaction costs were not excessive, the growing scarcity often brought willing buyers and sellers together in what is called a water market. The term ''water market'' lacks a precise definition, but once a few voluntary trades of water of relatively common physical and legal characteristics occur, it is said that a water market exists.

[3] When water trades in the western United States, either a water right is sold or use of the right is essentially leased for a period of time. Ownership of a water right conveys access to a specified quantity of water in perpetuity, subject to particulars such as priority, timing, and location. With a water ''lease'' as used herein, the holder of the right agrees to deliver, or allow the buyer access to, a certain quantity of water over a stated time period, subject to conditions such as timing and location of access. One-time transfers of water (essentially short-term leases) are sometimes called ''spot market'' trades or ''rental'' transactions. This paper reports on both sales and leases of water rights.

[4] Water markets require a well-administered system of transferable or leaseable water rights. As is well known, the doctrine of prior appropriation that underlies most water laws across the western United States allows for clearly defined and transferable water rights [*Hirshleifer et al.*, 1960], and state agencies or the courts administer and enforce those rights, although the states differ in how they implement the doctrine and administer the water rights systems [*National Research Council*, 1992].

[5] If water in a water short area were freely traded in an efficient market, water would be reallocated via trades to the point where each user was consuming at the point where the marginal value in all uses was identical (e.g., the marginal value in irrigation would equal the marginal value in municipal use or in in-stream recreation). In this ideal world, a single market price would emerge that would indicate the marginal value of raw water in that market area. However, in the real world, even in those locations where water markets exist, water rarely trades so easily or completely. Two reasons for this are lack of a homogeneous product and lack of market competitiveness.

[6] Lack of homogeneity is a natural consequence of how the prior appropriation doctrine accommodates the stochastic nature of streamflow. The doctrine deals with shortage by assigning priorities to water rights and temporarily canceling permission to divert based on those priorities, beginning with the most junior right and moving as far up the list of priorities as needed to assure delivery to more senior rights. Each individual right may have a unique priority date. Senior rights are worth more than junior rights because senior rights face less risk of shortage. If each right is uproduct is compromised. However,
within the overall structure of prior appropriation there exists a quite different approach known variously as proportional, fractional flow, or correlative rights [*Eheart and Lyon*, 1983]. With such rights, all users have equal priority, and shortage is accommodated in a given time period by lowering the allowable diversion for all users. The use of proportional rights is common in mutual ditch companies and water conservancy districts, wherein water is owned as ''shares'' or ''allotments'' (referred to generally as shares herein) of the total amount available [*Hartman and Seastone*, 1970]. Such organizations manage nearly half

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of the irrigation water in the West [*Thompson*, 1993]. Within these organizations all members essentially have the same priority, and the effect of a flow increase or decrease affecting the organization is distributed to the members in proportion to the number of shares each owns, thus providing homogeneity of product. The most active water markets deal in shares of such a company or district.

[7] A fundamental tenet of neoclassical economic theory is that competitive markets yield prices that reflect the true marginal economic value of the good being traded. Competitive markets have many buyers and sellers, do not artificially restrict price or ability to trade, have low transaction costs, allow an easy flow of information about prices and potential trades, and internalize all relevant costs and benefits of the transaction. Water markets typically fall short on one or more of these requirements. Many markets areas are so small that sellers and buyers are few. In others, laws, regulations, or customs limit price. In many water markets transaction costs are substantial, involving administrative and legal requirements [*Howe et al.*, 1990]. In many markets information is not readily available. Also, externalities commonly exist, especially in the form of changes in water quality and in-stream flow [*Howe et al.*, 1986; *Saliba*, 1987]. Some of these restrictions on the competitiveness of the market (e.g., a limited number of sellers) may elevate the price relative to the price that would be established in a purely competitive market, whereas others tend to depress the price (e.g., government subsidies, transaction costs, regulations or customs). Many of the restrictions, such as transaction costs, will also tend to limit the number of trades.

[8] Despite these limitations, water markets offer useful indications of the value of water, and have received considerable study. Studies of water markets have usually focused in detail on one or a few specific markets [e.g., *Hartman and Seastone*, 1970; *Colby et al.*, 1993; *Michelsen*, 1994; *Howe and Goemans*, 2003]. Only with a detailed examination can the numerous characteristics of the individual markets be given their due consideration. This study, to the contrary, takes a broad look across the western United States, emphasizing geographical scope rather than in-depth focus. This ''big picture'' approach offers a look at how prices in general have changed over the past few years and at how they differ across locations and across the purposes for which the water was purchased.

2. Methods

[9] The broad-scale examination of water prices described here is made possible by the *Water Strategist* and its predecessor the *Water Intelligence Monthly*, published by Stratecon, Inc., of Claremont, California, which have summarized many of the available western water market transactions in reports released on a monthly or quarterly basis. Fourteen years of transactions reported by these publications (1990–2003) were tabulated to provide the estimates presented herein of quantities of water traded and the price at which it trades. Other studies using the Stratecon data include those of *Brookshire et al.* [2004], who examined three market areas over 12 years, *Gollehon* [1999] and *Howitt and Hansen* [2005], who summarized 2- and 4-year sequences, respectively, and *Loomis et al.* [2003], who examined purchases for environmental purposes over 5 years.

[10] It is important to note that the Stratecon Inc. publications did not report on all transactions that occurred. Especially in the case of water leases, many trades were not summarized. First of all, the entries generally do not include the leases that occur within organizations such as mutual water companies and conservancy districts (however, within-organization sales are often included). A great deal of water is leased among share holders within organizations. For example, between 1993 and 1997 an average of 2153 lease transactions occurred each year, involving an average of 454,046 megaliters (ML) per year, within the Westlands Water District in California [*Carey et al.*, 2002] (1 ML = 1 million liters = 1000 m^3 = 0.81074 acre-feet). Similarly, the city of Fort Collins, Colorado, owns shares in several ditch companies as well as shares of a conservancy district; during the period 1990–2003 the city ''rented'' an average of 23,519 ML per year of that water, mostly to other share holders of the respective organizations. Within-organization leases, sometimes called ''institutional market'' leases [*Thompson*, 1993], are largely among irrigators, and the rules for transfer are often specified by the organization. Although doing much to improve the efficiency of water use, such leases are so common and numerous that they were not considered of primary interest by Stratecon Inc.

[11] Aside from within-organization leases, the publications missed some transactions. For example, most of the lease transactions along the Rio Grande in Texas reported by *Yoskowitz* [2002], and many of the non-CBT sales along the Colorado Front Range reported by *Howe and Goemans* [2003], were not listed. Neither are the included transactions a random sample. Nevertheless, the Stratecon publications contain the most comprehensive set of information available about water market trades in the western United States, information sufficient to roughly characterize the nature and extent of western water trades. It must be stressed, however, that the analysis described herein characterizes the Stratecon data, and thus largely fails to reflect within-organization leases and may fail to accurately represent the full population of other trades.

[12] Each water transaction entry in the *Water Strategist* or *Water Intelligence Monthly* briefly summarizes one or more actual trades. The entries typically include buyer, seller, purpose for which the water was purchased, type of transaction (whether sale or lease of a water right), and the source of the water (raw surface water, raw groundwater, effluent, or potable water).

[13] Buyers and sellers are categorized herein as one of the following: (1) municipality, (2) irrigator (farmer or rancher), (3) environmental protection entity (e.g., public trust concern, private entity such as the Nature Conservancy), (4) nonmunicipal water management organization (labeled ''WMO''), including federal or state government agencies, conservancy districts, and water districts, associations and companies, (5) other entity (e.g., power company, mining company, developer, investor, country club, feedlot, individual homeowner), or (6) several entities (several buyers or sellers of different types, such that the transaction could not be neatly assigned to one of the other categories). Transactions involving water banks are a special case; when the original seller and eventual buyer were reported they were tabulated as such, but when only a water bank was reported as the buyer or seller the bank was tabulated as a WMO.

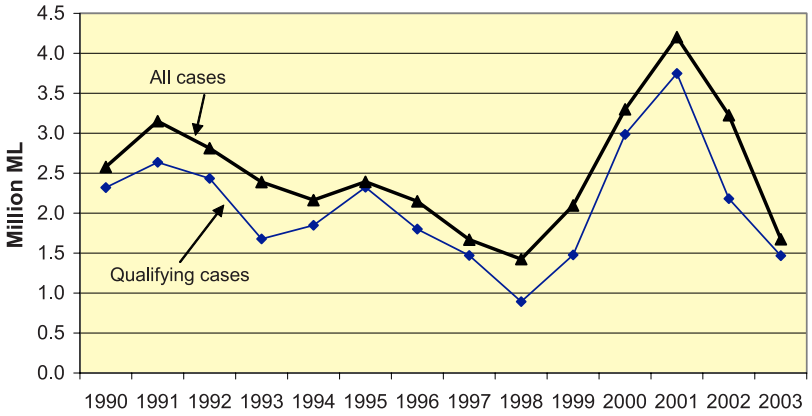

Figure 1. Trend in total volume of water transferred (1 ML = 0.81 acre-feet).

[14] The purpose for which the water was purchased was characterized herein as one of the following: (1) municipal or domestic (including commercial and industrial if serviced by a municipality, and including golf courses and other landscape irrigation), (2) agricultural irrigation, (3) environmental (e.g., in-stream flow augmentation), (4) other (including thermoelectric cooling, recreation, mining, aquifer recharge, augmentation of flows leaving the state per court order, supply to an individual business such as a feedlot or manufacturing plant, an investment of undefined characteristics, and unspecified uses), or (5) several (several purposes, such that the transaction could not be neatly assigned to one of the other categories).

[15] Some entries covered several related transactions. For example, several sellers or several buyers, or both, may have been included in the entry. Or several transactions within the same market may have been listed together in the same entry. Such entries were broken down into separate transactions for analysis if distinct prices were listed and different categories of buyers, sellers, or purposes were involved. After this disaggregation process, a total of 2450 transactions were available for the 1990–2003 period.

[16] The Colorado–Big Thompson (CBT) market is the most active market for water rights in the West, with up to 30 or more sales per quarter to municipalities alone (see *Hartman and Seastone* [1970], *Howe et al.* [1986], and *Michelsen* [1994] for descriptions of the market for CBT shares). It is also a market about which market information is readily available. The entries listed 949 CBT trades over the 14 years. Because the sale price for CBT shares differed little among trades completed during a given month, and because the volumes traded were typically small (averaging 49 ML), all CBT transactions of a single purpose within a given month were tabulated as one case for analysis in order to avoid having CBT transactions overwhelm the summary statistics. This aggregation process left a total of 228 CBT cases for the 14-year period, and thus a total of 1729 cases (2450–721) for analysis.

[17] Of these 1729 cases, 349 were omitted from further analysis because key information was missing (such as price or amount of water transferred), something other than raw water (i.e., effluent or treated water) was involved, the price included payment for things other than water and its management (e.g., land), or the transaction was not a market sale (e.g., it was an exchange or a donation). Thus 1380 qualifying cases (1729–349) were left for analysis. Figure 1 shows the total water volume by year of the qualifying cases and the full set of cases.

[18] Prices, reported by Stratecon Inc. on a per acre-foot basis, were converted to a per megaliter basis as required by the journal. Prices were adjusted to year 2003 dollars using the consumer price index. Lease prices are listed per year; sale prices are listed in total. Although mean prices are sometimes presented, this analysis emphasizes median prices, which more accurately indicate the price of a typical water trade when the price distributions are skewed.

[19] Prices paid for untreated water often include consideration for water management, including such services as storage and conveyance, in addition to the cost of raw water in the stream. The full value of water management may or may not be captured in annual assessment or conveyance charges. (Such charges were listed for 18% of the lease cases and 59% of the sale cases; the median charge when listed was $13 per ML.) These charges were not included in the tabulated prices because the focus here is on the value of water per se; however, we cannot be sure that the value of management is not still to some extent reflected in the tabulated prices.

3. Results

[20] All results presented herein are based on the 1380 cases meeting the criteria for further analysis explained above. Figure 2 shows the number of cases by a convenient geographic breakdown, climatic division (www.cdc.noaa.gov). Fourteen states have qualifying cases (all states in Figure 2 except North Dakota, South Dakota, and Nebraska). Three climatic divisions within these states have over 75 cases: division 4 in northeast Colorado, including Denver, Fort Collins, and other cities along the northern Front Range; division 5 in California, capturing the southern (San Joaquin River) portion of the Central Valley and on down to the Bakersfield area; and division 10 at the southern tip of Texas, along the Rio Grande as it enters the Gulf near Brownsville. Nine climatic divisions have between 26 and 75 cases: three in California, two in Texas, and one each in Arizona, Colorado, Idaho, and Nevada. Thirteen climatic divisions have between 11 and 25 cases, and 43 have from 1 to 10 cases. Another 45 climatic divisions in the 14 states have no cases.

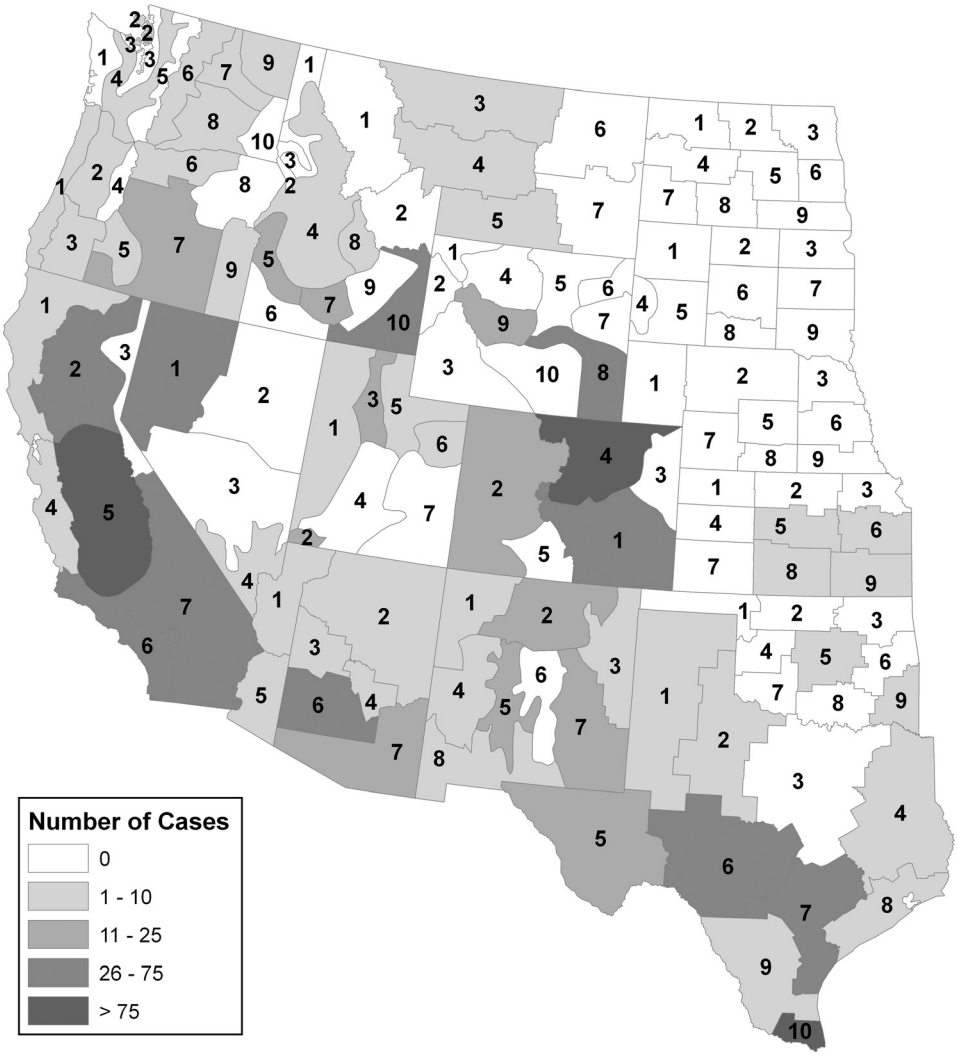

Figure 2. Number of cases meeting criteria for analysis of market prices, 1990–2003, by climatic division (divisions are numbered independently within each state).

3.1. Market Activity

[21] The 1380 cases involve a total of roughly 29 million ML (Table 1), or about 2.1 million ML per year on average. Ten percent (141) of the cases involve groundwater, with the remainder (1239) being of surface water. However, only 4% of the water transferred in these trades is groundwater, as indicated by the average water volumes per case, of 8238 ML for groundwater and 22,687 ML for surface water.

[22] The 14 states of Table 1 vary greatly in number cases. Three states (California, Colorado, and Texas) have over 200 cases each and together account for two thirds of the full set of cases, whereas seven states have fewer than 50 cases each and together account for only 12% of the cases. As seen in Figure 2, there is also great variation in number of cases across regions with a state. The most important factors affecting variation in frequency of trades among the western states and their climatic divisions are probably water scarcity in response to expanding demand, institutional and legal differences, and the existence (or absence) of water management organizations and associated infrastructure.

[23] Given the relative ease with which leases can be arranged, one would expect the incidence of leases to exceed the incidence of sales. This is indeed the case in 10 of the 14 states (Table 1, occurrence ratio column). The biggest exceptions are Colorado and Nevada, where sales were much more common than leases (although we must remember that within-organization leases are not included here). The prevalence of sales in these states reflects the relative ease with which sales can be consummated, especially for transmountain diversion water in Colorado that avoids return flow concerns on transfer, and the strong demand for secure water supplies by the fast growing cities along the Colorado Front Range and in Nevada's Las Vegas and Reno. In California, Washington, and Wyoming, and to a lesser extent Idaho, Oregon, and Texas, leases predominate. The reasons for the varying prevalence of leases undoubtedly are different across these states, but they probably have much to do with legal impediments to sales and the extent to which administrative requirements raise transaction costs. A full explanation of the reasons for the varying ratios of leases to sales across the states is beyond

Table 1. Western Water Market Activity by State, 1990–2003[a]

State	Leases			Sales			Occurrence Ratio (Leases/Sales)
	Number of Cases	Total Volume, 10^3 ML	Median Volume, ML	Number of Cases	Total Volume, 10^3 ML	Median Volume, ML	
Arizona	48	9581	24669	38	175	595	1.26
California	250	9638	18033	44	358	2362	5.68
Colorado	58	433	2261	369	111	73	0.16
Idaho	49	3418	21812	15	38	197	3.27
Kansas	11	11	322	5	3	493	2.20
Montana	5	19	4458	0	0	–	–
New Mexico	29	623	15442	30	24	125	0.97
Nevada	4	1516	17607	65	85	281	0.06
Oklahoma	2	1	463	1	99	98676	2.00
Oregon	34	263	2823	9	58	520	3.78
Texas	159	1366	3676	48	331	1019	3.31
Utah	11	111	11964	32	40	205	0.34
Washington	21	593	1744	4	102	2186	5.25
Wyoming	37	258	705	2	12	6202	18.50
All	718	27832	7308	662	1437	136	1.08

[a]Note 1 ML = 0.81 acre-feet.

the scope of this study and is an important avenue for further research.

[24] Over half (739) of the purchases were for municipal purposes, another 23% (322) were for agricultural irrigation, and 11% (150) were for environmental purposes (not counting where these purposes were included in the "several" category) (Table 2). The abundance of purchases for municipal purposes reflects the urban and suburban population growth in the western United States. Municipal water tended to be purchased as rights, whereas water for other uses, and especially for environmental purposes, tended to transfer as leases. All users probably value the security that owning water rights provides; municipal and industrial users are more likely than most other users to also have the ability to pay for water rights.

3.1.1. Amount of Water Traded

[25] Although the number of lease cases is only slightly larger than the number of sale cases (718 versus 662), 95% of the water transferred as leases, and this does not include the within-organization leases mentioned above. The median lease size is 7308 ML per case, compared with 136 ML for water right sales (the means are 38,763 and 2170 ML, respectively). Eighty-one percent of sales and 23% of leases involve fewer than 1000 ML, whereas 4% of sales and 47% of leases involve more than 10,000 ML. The largest leases tend to involve water associated with government-funded projects. For example, of the 37 cases (all leases) involving more than 150,000 ML, 14 involve Central Arizona Project water, five involve State Water Project (California) water, and seven involve Snake River (Idaho) water. The most important reasons for the large difference in volume transferred per case are that leases, because they are temporary, cost much less per unit of volume and are easier to arrange than purchases of rights. Leases are less expensive because of the obvious fact that they are usually for only one year, but also because they provide no security beyond the dates of the lease arrangement. Leases are easier to arrange because they face fewer outright prohibitions, incur lower transaction costs, and encounter fewer environmental regulations than do sales.

3.1.2. Who Sold to Whom?

[26] Water leases are common vehicles for most categories of buyers and sellers (Table 3). The most active categories of lessors were WMOs (water management organizations) and irrigators. The most common lessors among the WMOs were public agencies including the State Water Project and Central Valley Project in California, agencies managing Central Arizona Project water, and the U.S. Bureau of Reclamation in many states. Municipalities, irrigators, and WMOs are all common lessees.

[27] Sales of water rights were less dispersed across user class than leases (Table 4), with municipalities being the most common buyers (accounting for 37% of the purchases, not including their participation in the "several" category) and irrigators being the most common sellers (55% of all sales, not counting their participation in the "several" category). The only other large category of sellers, "other" (with 25% of the sales), includes most importantly developers, brokers, investors, individual landowners, and banks.

Table 2. Western Water Market Activity by Purpose of Purchase, 1990–2003

Purpose	Leases			Sales			Occurrence Ratio (Leases/Sales)
	Number of Cases	Total Volume, 10^3 ML	Median Volume, ML	Number of Cases	Total Volume, 10^3 ML	Median Volume, ML	
Municipal uses	286	6447	6167	453	938	204	0.63
Irrigation	199	5984	7578	123	107	52	1.62
Environment	113	4785	20691	37	234	416	3.05
Other	69	1349	2249	36	56	99	1.92
Several	51	9267	17811	13	101	48	3.92
All	718	27832	7308	662	1437	136	1.08

Table 3. Number of Western Water Leases From Seller to Buyer, 1990–2003

	Buyer						
Seller	Municipality	Irrigator	Environmental Organization	WMO	Other	Several	Total
Municipality	21	7	0	23	3	4	58
Irrigator	36	22	2	95	12	4	171
Environmental organization	0	0	0	1	0	0	1
WMO	43	64	1	126	23	55	312
Other	4	1	0	6	14	0	25
Several	25	20	0	27	20	59	151
Total	129	114	3	278	72	122	718

[28] The most common water right sale is from farmer (or rancher) to municipality. The principal reason that farmers more commonly sell water rights is probably that they claimed most of the early water rights, and thus control much of the water in the West. Sales by farmers to municipal uses are common for several reasons. First, it is often irrigated farmland that is converted to municipal use, and farmers usually sell their water along with their land. Second, farmers are susceptible to crop price fluctuations and occasionally find themselves in tenuous economic circumstances and in need of cash, and cities, which value the security of owning water rights, are ready buyers. Also, farmers can, except in exceptionally dry years, often lease back the water they sold to cities.

[29] Knowing the type of buyer does not necessarily indicate the purpose for which the water was purchased, especially when the buyer was a WMO. Most importantly, Tables 3 and 4 underplay the importance of irrigators are as a source of water for municipal use. Looking at the purpose for which the water was purchased, we find that 63 of the leases from irrigators were for municipal uses although only 36 of the leases were from irrigators to municipalities (Table 3), and that 229 of the purchases of rights from irrigators were for municipal uses although only 141 of the sales were directly from irrigators to municipalities (Table 4). Also note that there were 312 leases from WMOs (Table 3) and much of that leased water previously had been used by irrigators. The importance of irrigation as a source of water for trade is suggested by the fact that in 1995 over $^3/_4$ of the total water withdrawals in the 14 states at issue were for irrigation [*Solley et al.*, 1998].

3.1.3. Is Market Activity Increasing?

[30] *Young* [1986, p. 1143] wrote, "Economists have been warning for years that increasing scarcity and costs of unappropriated water supplies together with limited public budgets and the environmental costs of new projects would shift attention to nonstructural approaches, particularly to the market mechanism, to meet emerging needs. Change, however, appears to be slow." During the intervening 20 years the constraints on new water projects (scarcity of good sites, environmental concerns, lack of public funds) have remained, and the population of the 14 western states of interest here has continued to increase (e.g., by 20% from 1990 to 2000), so the incentives for water market activity have only intensified. Has this led to more market activity?

[31] Combining across all states and water uses (Figure 3), the number of leases per year has increased significantly over the past 14 years (the Mann-Kendall test for time trends yields a test statistic, k, of 3.23, substantially above the 1.96 cutoff for the 0.95 probability level), whereas the numbers of sales of rights show no trend ($k = -0.44$). Looking separately at the major water uses, among leases (Figure 4), the number of purchases for environmental purposes increased significantly ($k = 3.23$), but the increases for municipal and irrigation purposes were not significant ($k = 1.81$ and 1.42, respectively). Finally, among sales (Figure 5) the number of purchases for environmental purposes increased significantly ($k = 2.35$), but the increase for municipal uses is not significant ($k = 0.99$) and the number purchases for irrigation declined significantly ($k = -2.79$).

[32] Note the spikes in purchases for municipal use in 1991 and 1999 (Figures 4 and 5). The 1991 increase in leases for municipal uses occurred mainly in California, spurred by a 5-year drought and the beginning of operation of the California Water Bank [*Loomis*, 1992]. The 1999 increase in leases occurred largely in California, Kansas, and Texas, and the increase in sales occurred mostly in Nevada and Utah. The reasons for these increases are not clear; 1999 was not an exceptionally dry year in those locations. A more thorough investigation of these spikes than was attempted in this study would examine weather

Table 4. Number of Western Water Right Sales From Seller to Buyer, 1990–2003

	Buyer						
Seller	Municipality	Irrigator	Environmental Organization	WMO	Other	Several	Total
Municipality	5	1	0	2	3	0	11
Irrigator	141	75	8	62	27	52	365
Environmental organization	1	0	1	0	0	0	2
WMO	17	3	1	24	5	4	54
Other	54	10	1	39	53	2	159
Several	28	1	0	13	1	28	71
Total	246	90	11	140	89	86	662

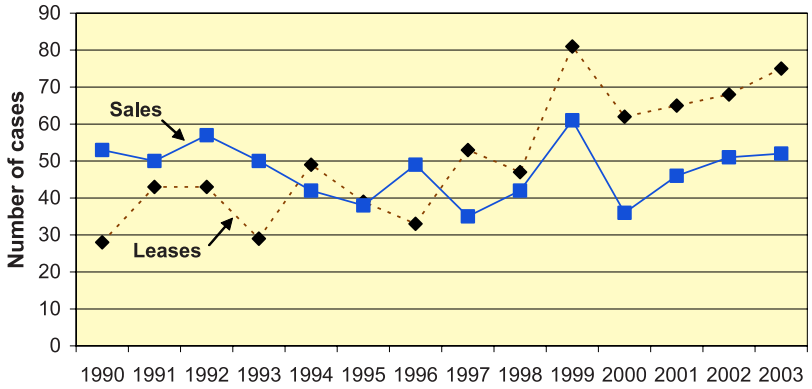

Figure 3. Trend in water market activity, all water uses.

and reservoir storage levels in water source areas that may be far from the use locations. For example, the lower Rio Grande in Texas receives its water largely from upstream states and Mexico, and southern California diverts a substantial amount of water from the Colorado River.

[33] Assuming that Stratecon Inc. did not change its methods from 1990 to 2003, we conclude that the number of leases has indeed increased, roughly doubling over the 14-year period (Figure 3), but that the number of sales has not increased. Four sets of reasons for a lack of water market activity are commonly cited [see, e.g., *Young*, 1986; *Getches*, 1987; *Thompson*, 1993]. First, the local/regional nature of rivers and groundwater aquifers, along with the costs of storing and transporting water, often limit the size of the market, sometimes to few buyers and sellers. Second, moving water from one location to another incurs opposition because of impacts on downstream junior right holders, in-stream flow concerns [*Gillilan and Brown*, 1997], and third-party financial impacts [*Howe and Goemans*, 2003; *Hanak*, 2005]. Third, even in the absence of opposition, transaction costs can be substantial for some kinds of trades [*Howe et al.*, 1990]. Fourth, many larger water projects were publicly financed, and with that financing often came constraints on water transfers [*Wahl*, 1989]. The first of these reasons applies equally to leases and sales, but the other three reasons are all more salient when moving water across space has long-term, as opposed to only short-term, consequences, and probably go a long way toward explaining the lack of growth in numbers of sales.

3.2. Price of Water

[34] The Stratecon Inc. data allow consideration of several interesting questions regarding water market prices. Following a general description of variation in price across states and water uses, this section compares aggregate lease and sale prices, examines aggregate price trends, tests for the influence of several factors on individual transaction price, and finally takes a closer look at a few selected markets.

3.2.1. Variation in Price Across States and Water Uses

[35] The price distributions for individual states and water uses are wide and skewed. For leases most minimums are near \$0 per ML and most maximums are in the \$100s, and for sales nearly all minimums are below \$500 and most maximums are in the \$1000s. For most states and water uses, a few cases with unusually high prices skew the price distribution. Across the full set of leases the mean price is \$69 per ML per year versus a median of \$38, and for sales the overall mean is \$2948 versus a median of \$1955. As mentioned above, we will focus on medians.

[36] Median lease prices vary substantially among the states, ranging from below \$10 per ML in Idaho, Oregon, Utah, and Wyoming to at least \$45 per ML in Arizona, California, and New Mexico (ignoring Montana, Nevada

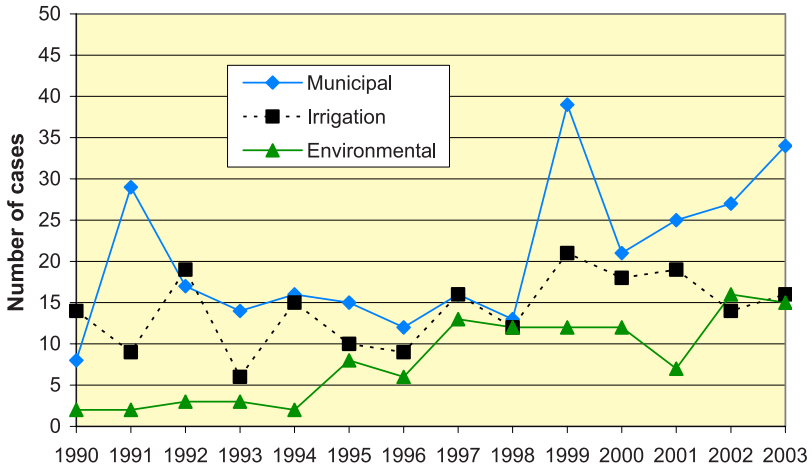

Figure 4. Trend in number of leases for municipal, irrigation and environmental purposes.

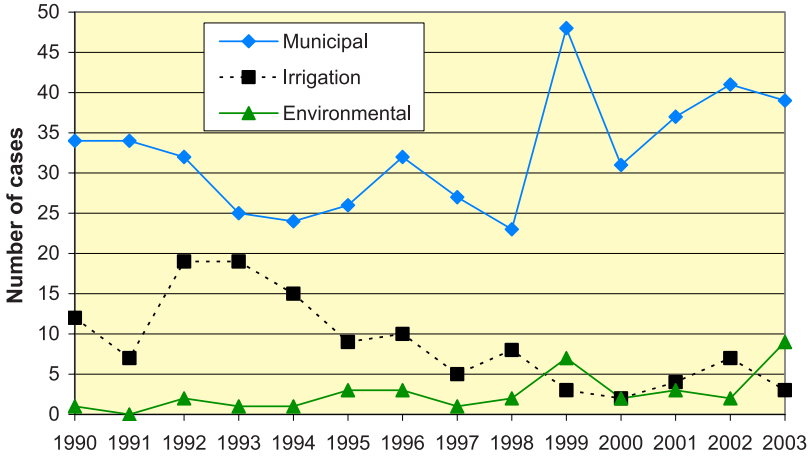

Figure 5. Trend in number of rights purchased for municipal, irrigation, and environmental purposes.

and Oklahoma because of the small numbers of cases, Table 5). Median sale prices also vary substantially across states, ranging from below $100 per ML in Idaho to over $2000 in Colorado, New Mexico, and Nevada (ignoring Kansas, Oregon, Washington, and Wyoming because of the small numbers of cases). Prices of both leases and sales are relatively low in Idaho, Oregon and Utah. There is no apparent relation between number of cases and median lease price, but median sale price is positively related to number of cases ($R^2 = 0.26$). The variance in price across states undoubtedly reflects a variety of factors including relative scarcity, the availability of publicly managed water, and state and local institutional differences. Further research is needed to more precisely understand the reasons for the interstate differences.

[37] Median lease prices also vary substantially among purposes for which the water was acquired, with municipal uses tending to pay more than irrigation and environmental uses (Table 6). For leases the median price paid for municipal uses ($56 per ML) was 4.6 times that paid for irrigation water ($12) and 1.5 times that paid for environmental purposes ($38). For sales the median price for municipal uses ($2120 per ML) was only slightly larger than that paid for irrigation water ($1917) but 3 times that paid for environmental purposes ($706). The reasons for the higher prices for municipal water are of two types. First, as discussed below, prices of water for irrigation and environmental uses are sometimes artificially low. Second, it is the nature of cities that they value and have a relatively high ability to pay for a secure water supply, and that expanding urban water demand tends to raise prices.

[38] The relatively low lease price paid by irrigators reflects the existence of many, typically long-standing arrangements whereby farmers lease excess water at comparatively low prices from cities, WMOs, or other irrigators. Often the lease price is set equal to the annual assessment fee charged by the ditch company or other WMO, a fee that may itself reflect a publicly subsidized storage and delivery infrastructure. Such trades may also enjoy relatively low transaction costs. However, to obtain water rights farmers nowadays usually must compete with other buyers on the open market.

[39] Nearly all (105) of the 113 leases for environmental purposes were purchased by governmental entities (including federal agencies such as the Bureau of Reclamation and various state and county entities) that were typically buying the water for aquatic species protection pursuant to the Endangered Species Act. In general, these leases were emergency measures to augment flows during dry times. Prices of water rights obtained for environmental purposes (most of which were purchased by government agencies and environmental organizations) were less likely than were leases to have been affected by extreme weather conditions. In addition, the transaction summaries indicate that prices of water rights sold for environmental purposes were sometimes discounted, apparently reflecting either tax benefits of such sales or perhaps sellers' appreciation of the public benefits of environmental protection.

3.2.2. Comparison of Lease and Sale Prices

[40] Tables 5 and 6 list the implicit capitalization rate (ICR), which is the rate at which perpetual annual payments at the lease price must be discounted to yield a present value equal to the sale price, and was computed in percentage terms as 100 times the median lease price divided by the median sale price [see also *Howitt and Hansen*, 2005]. Over all cases the ICR is 1.94%, much below the commercial capitalization rate of roughly 8%. Such a low ICR indicates that purchasers of water rights are paying a substantial

Table 5. Western Water Market Prices by State, 1990–2003

State	Median Price[a]		ICR, %
	Leases[b]	Sales	
Arizona	47	1080	4.35
California	55	991	5.59
Colorado	15	2278	0.66
Idaho	6	78	7.75
Kansas	40		
New Mexico	45	2055	2.18
Nevada		2946	0.00
Oregon	7		
Texas	24	656	3.63
Utah	6	470	1.23
Washington	30		
Wyoming	6		
All	38	1955	1.94

[a]Year 2003 dollars per ML. Median prices are listed only if at least 10 cases are available.
[b]Dollars per year.

Table 6. Western Water Market Prices by Purpose of Purchase, 1990–2003

Purpose	Median Price[a]		ICR, %
	Leases[b]	Sales	
Municipal uses	56	2120	2.64
Irrigation	12	1917	0.65
Environment	38	706	5.37
Other	53	1519	3.47
Several	43	1664	2.57
All	38	1955	1.94

[a]Year 2003 dollars per ML.
[b]Dollars per year.

premium. For example, at an 8% capitalization rate, a lease price of $38 per ML implies a sale price of $475, far lower than the $1955 found for the median price among the 622 sale cases. The premium is most likely incurred to avoid the possibility of rising lease prices or the uncertainty of finding water for lease, but also may reflect expectation on the part of water right buyers that real prices of water rights will increase.

[41] It should be noted, however, that the overall ICR is influenced by the relatively low lease rate for irrigation water mentioned above. Also, the overall sale price is heavily weighted by data from Colorado; over half of the sales are from Colorado, a state where the median sale price is relatively high; fully 94% of the sale cases for Colorado are for markets along or east (downstream) of the northern Front Range (i.e., in climate division 4, Figure 2). Without Colorado the overall ICR is 4.01%.

[42] The ICRs vary substantially across the states, from 0.66% for Colorado to 7.75% for Idaho. The variance across states is probably a reflection of differences among states in the purposes for which water rights tend to be leased or sold and in legal or institutional constraints on different kinds of water transfers. For example, in Colorado and California purchases for municipal purposes are most common (Table 7). In Colorado 90% of the municipal use cases are sales, whereas in California 78% of such cases are leases. Because municipal buyers tend to pay relatively high prices, we would expect Colorado's ICR to be below California's.

[43] The ICRs also vary among the water uses, from 0.65% for irrigation water to 5.37% for environmental water (Table 6). As with variance across states, variance in ICR across water uses probably reflects a variety of special circumstances. Prices of leases for irrigation water, as mentioned above, are often kept low by custom or institutional constraint, whereas sales of rights to irrigators are generally unconstrained; and for environmental purposes leases have tended to be emergency purchases by public agencies whereas sales have often been at unusually low prices. The ICR of water purchased for municipal use (2.64%) is probably relatively free of special influences on price, and thus is a truer measure of the risk premium and effect of speculation.

3.2.3. Are Prices Rising?

[44] The lack of increase in the number of water right sales, in light of the West's population increase, suggests an increasing price trend, at least for rights purchased for municipal use. Expectations about trends in lease price are not so obvious, as the number of leases has been increasing. In this section we first look at trends in overall lease and sale prices and then at trends in prices of water purchased for specific purposes.

[45] Trends in median prices paid for leases and sales (across all states and purposes) are shown in Figure 6. The unusually high median lease prices in 1991 and 1992 reflect a threefold increase in the number of lease entries in California, where lease prices were relatively high in the early 1990s, spurred by a 5-year drought and the preponderance of leases for municipal use [*Loomis*, 1992]. The Mann-Kendall test does not find a significant increase in median lease price (k = 1.00), although since 1994 prices have obviously been rising. However, as expected, median sale prices have risen significantly over the 1990–2003 period (k = 2.08).

[46] Looking at the three major uses for which water was purchased, median prices of leases for municipal use show a nonsignificant downward trend (k = −1.75); this trend is heavily influenced by the California leases in the early 1990s mentioned above. Median prices of sales for muni-

Table 7. Number of Cases by Purpose of Purchase by State, 1990–2003

State	Leases			Sales		
	Municipality	Irrigator	Environmental Organization	Municipality	Irrigator	Environmental Organization
Arizona	16	11	5	31	1	0
California	116	61	48	33	5	3
Colorado	24	13	7	226	97	12
Idaho	3	21	17	2	10	2
Kansas	9	2	0	5	0	0
Montana	0	1	3	0	0	0
New Mexico	2	2	10	24	2	0
Nevada	2	0	0	57	0	7
Oklahoma	2	0	0	1	0	0
Oregon	0	19	11	0	1	8
Texas	95	38	0	46	2	0
Utah	2	9	0	26	4	2
Washington	2	5	12	1	0	3
Wyoming	13	17	0	1	1	0
All	286	199	113	453	123	37

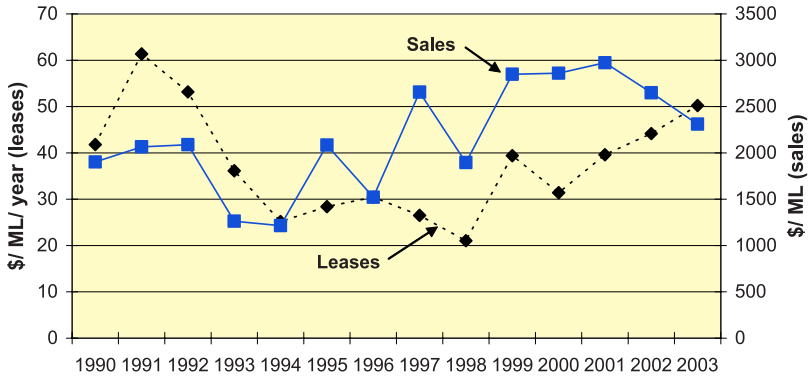

Figure 6. Trend in median price of water, all water uses (year 2003 dollars).

cipal uses have increased significantly (k = 2.19). For irrigation water, median prices of leases have fallen (k = −2.63) and median prices of sales do not show a significant trend (k = 1.09). For environmental purposes, prices of leases have risen significantly (k = 2.52) but prices of sales have not (k = 0.48) (though for sales there are so few cases that the trend test is of little interest).

3.2.4. What Affects Transaction Price?

[47] The price at which water changes hands in a given trade may be influenced by a large number of factors, including number of buyers and sellers in the market, existence of available storage and delivery infrastructure, transaction costs, institutional arrangements, climate, amount of water transferred, and, to the extent that laws, administrative requirements, or customs differ across uses, the use for which the water is purchased. The first four of these variables are very difficult to measure, especially across so many market areas as are covered by the current data. The analysis presented below is modest in comparison with what might be accomplished with more effort, but it is nevertheless instructive.

[48] For this analysis seven independent variables were regressed on price using OLS. This was done separately for leases and sales, and included only those cases for which the purpose of the purchase was municipal, irrigation, or environmental use. The seven independent variables are year of the transaction (YEAR), a measure of drought (PDSI), megaliters transferred (ML), year 2000 population of the county of the buyer (or, if the buyer's location could not be identified, of the seller) (POP), a dummy variable for groundwater (GW) with the alternative being surface water, and dummy variables for municipal use (MUN) and environmental use (ENV) with the alternative being irrigation use. Ideally the population variable would focus on population of the market area of each transaction rather than on the county, but, as mentioned earlier, delineating the hundreds of market areas involved would be a formidable task. The climate variable (PDSI) was constructed from the monthly Palmer Drought Severity Index numbers for the period 1990–2003 for the climatic divisions with qualifying cases (see Figure 2). This index measures the deviation from climatic norms [*Alley*, 1984]. The monthly index numbers for the relevant climatic division for the six months prior to the transaction were averaged to compute PDSI for each case. PDSIs vary from about 4 for extremely wet conditions to about −4 for extreme drought. Because this measure reflects only data from the surrounding climatic division, it may fail to capture the effect of weather changes on water availability in those cases where the water originates upstream of the climatic division. Also, because the measure uses data for only the past 6 months, it will be less sensitive in situations with ample reservoir storage.

[49] In the regressions we would expect, all else equal, the price per unit of volume to be larger (1) during times of drought for leases (because leases are generally short-term arrangements and thus able to respond to temporal climatic variation); (2) for small sales (because transaction costs can be substantial for sales and are likely, as reported by *Howe et al.* [1990], to decrease per unit of water as amount of water sold increases); (3) in areas with greater population (because demand for water increases as population grows); and (4) for surface water versus groundwater for sales (because of dropping water tables over the long term). Given the examination of trends in median price presented above, we also expect to find (5) that sale prices have increased over the 14-year period but that lease prices have not. Also, given the prior examination of median prices for different water uses we expect to find (6) for leases that prices of water purchased for irrigation are lower than those of water purchased for municipal and environmental uses and for sales that prices of water purchased for irrigation are lower than those of water purchased for municipal uses but higher than those of water purchased for environmental uses.

[50] Tables 8 and 9 list the results of the two regressions. Both regressions are significant, although they explain a modest amount of the variation in market price (adjusted R^2 values are 0.21 for leases and 0.24 for sales). For leases, higher prices are associated with drier climates and larger county populations. Lease price is greater for municipal and environmental uses than for irrigation. The influences of YEAR, ML, and GW are not significant. For sales, higher prices are associated with more recent sales, smaller volumes of water transferred, smaller county populations, and with surface water as opposed to groundwater. Sale price is also greater for municipal uses and less for environmental uses than for irrigation. The influence of PDSI is not significant.

[51] The regression results are discussed in turn. (1) For drought the results are in line with expectations, in that lease price is greater in times of drought. The lack of significance of PDSI for sales is reasonable given that sales are in perpetuity and generally take considerable time to arrange. (2) The results for transaction size, that sale price drops with

Table 8. Regression Analysis of Influences on Lease Price[a]

Variable	B	Standard Error	Beta	t	Significance
(Constant)	1796.847	1325.350		1.356	0.176
YEAR	−0.891	0.664	−0.050	−1.342	0.180
PDSI	−3.459	1.129	−0.113	−3.063	0.002
ML	−1.088E-05	0.000	−0.010	−0.281	0.779
POP	7.538E-06	0.000	0.277	6.820	<0.001
GW	12.353	9.443	0.051	1.308	0.191
MUN	44.156	6.163	0.309	7.165	<0.001
ENV	28.995	7.654	0.158	3.788	<0.001

[a]Lease price $/ML/year for 2003 dollars. N = 593, adjusted R^2 = 0.214, F = 24.027, and significance <0.001.

size, is also expected. The lack of significance of ML for leases suggests that transaction costs are not as important an influence on lease price as they are on sale price. (3) The results for county population are in line with expectations for leases (i.e., price increases with population) but not for sales. The negative POP coefficient for sales may in part reflect the particular locations of the counties with the largest populations, which were Los Angeles, San Bernadino, Alameda, and San Diego counties in California, Maricopa and Pima Counties in Arizona, Bexar County in Texas, and Salt Lake County in Utah. Sales in most of these counties typically involved water managed under administrative constraints. This unexpected finding highlights the need to understand and account for the institutional characteristics of each market, a task that was beyond the scope of this broad-scale assessment, and may also suggest that counties are not the best geographical units for characterizing population. (4) The results for water source, that sale prices are lower for ground than for surface water, are in line with expectations. The lack of significance of GW for leases is reasonable in that leases are typically for a specific amount of water. (5 and 6) The remaining results, regarding time trend and water use, are consistent with prior discussions.

3.2.5. Price Differences Across Selected Markets

[52] For most markets the number of qualifying cases is small, usually below ten, but for some there are enough cases to examine market-specific trends and to compare water uses or types of transfer (leases versus sales). Here we examine a few of the markets for which several cases are available, allowing discussion of some key market influences.

[53] Figure 7 shows median lease prices for two markets, one along the North Platte River in Wyoming and the other along the Rio Grande in Texas. For each market, Figure 7 distinguishes between the two most common uses for which water was purchased, irrigation and municipal use. Along the North Platte, the Bureau of Reclamation supplied the water, which was stored in Glendo Reservoir, at nominal prices of $4 per ML for irrigators and $61 per ML for M&I uses. These administratively set fees remained constant over the 10-year period (1994–2003) for which leases were recorded; the median prices of Figure 7 are updated to year 2003 dollars. Many of the lease prices for other locations in the database were apparently also administratively set, although constant prices enduring over several years were unusual.

[54] The Rio Grande market in Texas is an example of competitive lease prices. The Rio Grande Watermaster's office facilitates the market by bringing buyers and sellers together, with the price being determined by negotiation between buyer and seller [*Yoskowitz*, 1999]. As seen in Figure 7, prices for irrigation and municipal water are similar in all years; overall medians, which represent 37 trades for irrigation and 64 trades for municipal use, are both $19 per ML. *Yoskowitz* [2002] reports on a much larger set of lease transactions that occurred along the Rio Grande in Texas between 1993 and 2000, a few of which were for mining. Mean prices paid for irrigation and municipal water among the full set of leases were both $18 per ML in nominal dollars. Interestingly, the mean price paid by mining firms was $350, demonstrating that even in a competitive market anomalies can occur (see *Yoskowitz* [2002] for details).

[55] Figure 8 shows median prices for sale of water rights, specifically, shares of WMOs, from three water markets along the Colorado Front Range and in eastern Colorado. Water from Twin Lakes Reservoir (174,000 ML

Table 9. Regression Analysis of Influences on Sale Price[a]

Variable	B	Standard Error	Beta	t	Significance
(Constant)	−719961.257	64642.228		−11.138	<0.001
YEAR	362.029	32.403	0.422	11.173	<0.001
PDSI	−39.207	47.229	−0.031	−0.830	0.407
ML	−5.488E-02	0.015	−0.131	−3.635	<0.001
POP	−3.713E-04	0.000	−0.145	−3.909	<0.001
GW	−1904.010	420.292	−0.173	−4.530	<0.001
MUN	1118.370	328.737	0.138	3.402	0.001
ENV	−2066.933	605.172	−0.138	−3.415	0.001

[a]Sale price in $/ML for 2003 dollars. N = 613, adjusted R^2 = 0.239, F = 28.450, and significance <0.001.

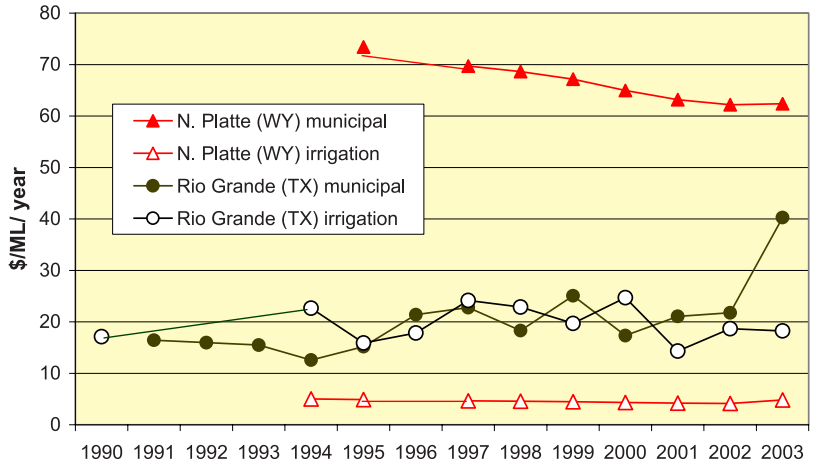

Figure 7. Trend in median price of water leases in two markets (year 2003 dollars).

of capacity), located along the Arkansas River a few miles south of Leadville, serves users in a variety of locations, including south Denver suburbs such as Aurora, the Colorado Springs area, locations along the Arkansas River including the Front Range city of Pueblo and farming areas further downstream. Twin Lakes water is diverted from the Colorado River drainage, and thus was new to the eastern side of the continental divide when the diversion was created. The prices for Twin Lakes water in Figure 8 represent 14 sales. Prices have been relatively high, typically above $5000 per ML, because of the economic and population growth and dwindling groundwater supplies along parts of the Front Range, and because of the 1995 Supreme Court decision in *Kansas v. Colorado* that required the Upper Arkansas Water Conservancy District to augment streamflow to make up for reduced flows attributable to past pumping along the Arkansas River in Colorado [*Naeser and Bennett*, 1998].

[56] The CBT market (Figure 8) reflects sales of water managed by the Northern Colorado Water Conservancy District and delivered to 30 cities and towns and about 240,000 hectares of farmland in the South Platte drainage. Water in the CBT project is managed using six major reservoirs with a combined storage capacity of over 1.2 million ML, 56 km of tunnels, and 153 km of canals. As with Twin Lakes, the water is diverted from the Colorado River drainage. The median prices in Figure 8 represent 213 cases. The price began increasing in 1995 and rose dramatically in 2000, largely in response to urban expansion. *Michelsen et al.* [2000] present an analysis of 30 years of CBT rights transactions showing that speculation also probably plays a role in market price. Over half of the CBT shares are now owned by cities [*Howe et al.*, 1986; *Michelsen*, 1994; *Howe and Goemans*, 2003].

[57] The Windsor Reservoir and Canal Company operates 6 reservoirs with a combined storage capacity of 80,000 ML, and provides irrigation water to roughly 22,000 hectares in Larimer and Weld Counties. Most of the company's annual delivery of about 38,000 ML is direct flow water from the Cache la Poudre River, although it also receives about 6,000 ML of water from another basin. The median price, which represents 11 sales, has remained relatively stable, ranging from about $800 to $1600 per ML. In comparison with the other two markets,

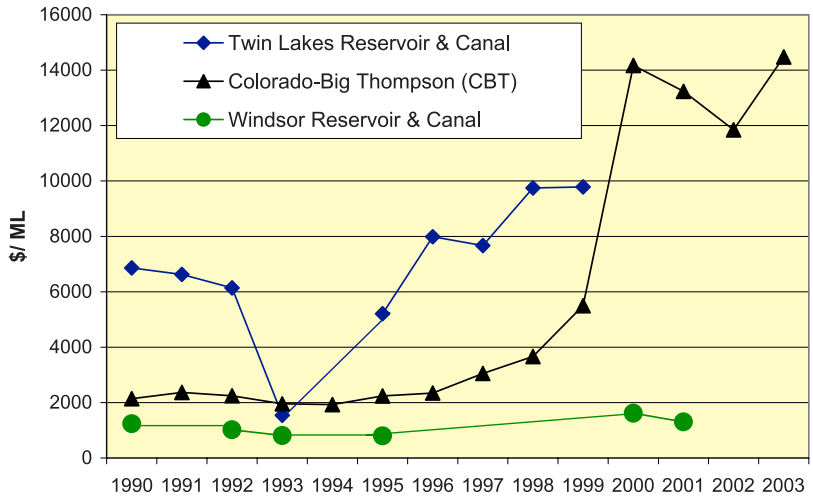

Figure 8. Trend in median price of water rights in selected Colorado Front Range markets (year 2003 dollars).

the storage capacity and delivery area are small and the water users are more heavily concentrated in agriculture, which in part accounts for the relatively low price.

[58] Two main points are evident from this comparison of Colorado Front Range water rights markets. First, prices can vary substantially even among markets located quite close to each other. Such markets are distinguished by local economic conditions, availability of alternative supplies (such as groundwater as a supplement for surface water), extent of their water distribution infrastructure, past decisions to obtain secure surface water rights, and return flow considerations. Second, prices in competitive markets can change dramatically over time in response to development pressures.

4. Conclusions

[59] At least six conclusions can be drawn from the analysis of the trades reported by Stratecon Inc. First, much more water changes hands each year via leases than via sales of water rights, in part because the median size of leases is over 50 times that of sales. Being relatively short-term, leases generally incur lower transaction costs and fewer legal and administrative constraints than permanent sales. Of course, leases of a water right can occur repeatedly, whereas a sale is in perpetuity, so the comparison of leases to sales is in a sense an unfair one.

[60] Second, water market activity and price are geographically variable. Markets are very active in a few areas of the West, but other areas appear to have had relatively few trades over the past 14 years. The median price of water is highly variable both within and across states, reflecting the particular physical, legal, administrative, and economic characteristics of individual water markets. In addition, lease price varies over time in response to weather cycles, and both lease and sale prices respond to development pressures. Such variability complicates the process of benefit transfer.

[61] Third, except for within-organization leases, which were generally not included in the transaction data analyzed here, WMOs (especially public agencies) and irrigators are the most common lessors, but lessees are fairly well distributed across the various categories of buyers. With sales, irrigators are by far the most common sellers and municipalities are the most common buyers. Purchases for municipal purposes have tended to be of water rights, whereas purchases for irrigation, environmental, or other purposes have tended to be of leases.

[62] Fourth, across the complete set of cases, prices paid for municipal water tend to be higher than prices paid for water to be used for irrigation or environmental purposes. However, numerous exceptions to this general finding exist, such as the lower Rio Grande lease market and the CBT water rights market, where competition tends to equalize prices (although even in these markets exceptions occur). Fifth, market leasing activity appears to be increasing, although sale activity is not. Sixth, real sale prices have been increasing, and in recent years so have lease prices.

[63] The first two of these conclusions can be said with confidence to apply to the full population of western water trades. Because of the sampling procedure employed by Stratecon Inc., the other conclusions are best characterized as hypotheses. In addition to future testing of these hypotheses, useful areas for future research include (1) adding comprehensive data on within-organization leases and (2) achieving a more complete analysis of the factors affecting variance in incidence and price across market areas and water uses. The latter effort would require including variables describing the different laws and administrative arrangements affecting market activity and price.

[64] Finally, it bears repeating that although water market activity offers important information about the value of water, water values are highly variable both geographically and over time, and are commonly affected by factors that interfere with competitive pricing, so care must be used in applying water market prices to analyze policies affecting water supply.

[65] **Acknowledgment.** The author thanks Alex Bujak, research assistant with Colorado State University, who ably helped summarize the transactions and maintain the database, and the journal's reviewers for insightful and helpful comments.

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