Water Markets: Western Water Transfers from Agriculture to Urban Uses, 1987-2005

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Abstract

There is considerable pressure to re-allocate water from traditional agricultural uses to meet growing urban demand. For a variety of reasons, water markets are more complicated than are those for other resources, such as land. In this paper we describe water markets and some of the legal and regulatory issues affecting them and present a new data set that provides the most comprehensive view of water allocation and trading available. The data detail how water currently is transferred within and across two major sectors, agriculture and urban. It also reveals the contractual forms used

Introduction.

Farmers in the American West use roughly 80 percent of the region's water, often in low-valued or subsidized crops, such as alfalfa, cotton, or rice. Farmers typically pay only for the pumping or conveyance costs for the water and not for its scarcity value.[1] Accordingly, much water use in agriculture is of low value, whereas at the margin, water values are much greater in urban areas. As a result, there are significant allocative gains from moving some water from agricultural to urban uses.

In 1992, Griffin and Boadu reported that the value of water used in agriculture, capitalized over 50 years, was $300 to $2,300 per acre-foot (approximately 326,000 gallons) in the Rio Grande Valley of Texas. Urban water values, capitalized over the same period, ranged from $6,500 to $21,000 per acre-foot. The average transfer produced net benefits of $10,000 per acre foot.[2]For more contemporary evidence, in California, an acre-foot used in the semiconductor industry produces $980,000 in gross state revenue; that same acre-foot used to grow cotton and alfalfa generates $60.[3] Groundwater for farming near Marana, Pima County, Arizona costs approximately $25 per acre-foot, whereas the same water for Tucson costs $700.

[1] Glennon (2005,1883-85). As pointed out by Hanemann (2005, note 29), this conditional also is historically true for urban areas where metering did not become common until well into the 20th century.

[2] Griffin and Boadu (1992, 274-5).

[3] See Peter Gleick, *Pending Deal Would Undermine State's Water Solutions*, Sacramento Bee, Feb. 25, 2005, at B7.

In recent efforts to secure Imperial Irrigation District water, San Diego offered $225 per acre-foot for water that farmers in the Imperial Irrigation District paid $15.50. Even more dramatically, while farmers in the Imperial Irrigation District paid $13.50 per acre-foot in 2001, a development near the South Rim of Grand Canyon National Park was prepared to spend $20,000 per acre-foot to deliver the same Colorado River water.[4]

Such disparities of value at the margin in the use of a resource have occasioned calls for the reallocation of water from low-value to higher-value activities through water marketing. Such trades are beneficial to both parties; farmers can receive more from some of their water than they could earn in agriculture and cities, as well as environmental and recreational uses, can secure additional water at lower cost than alternatives, such as desalinization. Indeed, in the past 20 years, rapid population growth, urbanization, a rise in the contribution of manufacturing and services along with a relative decline in agriculture, and increased environmental concerns have underscored the need to develop water markets for the smooth, incremental transfer of water as values change.

As the legal summary below makes clear, however, water markets are more complex than are those for land for example. Property rights to water, in general are less complete due to the mobile and uncertain nature of water supplies and the fact that individuals have usufruct rights, subject to state oversight.[5] Further because there are often simultaneous and sequential users of the same water, water trades that change the location, nature and timing of use, as is likely the case with most agriculture-to-urban transfers, are regulated by the states to limit harm to third parties. Third-party objections to water transfers can slow, limit, or block water trades.

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[4] See Glennon, *Water Follies* (2002).
[5] Sax (1990, 260), Gray (1994b, 262).

Nevertheless, in the face of growing urban demand, water transfers are taking place. The major objective of this article is to document how much water marketing has occurred, to show the sectors and states involved, to describe contractual forms used, and to illustrate the trend in water markets. To our knowledge this is the first comprehensive analysis of the extent of western water markets.

We report annual water transfers from 1987 through 2005 as listed in the trade journal, *Water Strategist*. The *Water Strategist* is a monthly publication that details transactions, litigation, legislation, and other water marketing activities. It is self-advertised as "the only source of published information on water transactions in the West".[6] Each month, the *Water Strategist* publishes a "Transactions" section that lists, by state, each water transfer that occurred. From the publication, we can learn all or some subset of the following: the year of the transfer; the acquirer of the water; the supplier; the amount of water transferred; the proposed use of the water; and, if applicable, the terms, such as the price and nature (lease or sale) of the contract. Necessarily, any transactions that are not included in the journal will not be in our data set. Even so, its listings are viewed as the most comprehensive available across the states and hence, will capture the general pattern of water trading.

Before turning to the data, it is important to summarize the nature of appropriative water rights and legal and regulatory issues that affect water markets. We also briefly discuss some of issues raised in the economics literature that relate to water transfers.

II. Appropriative Water Rights and State Regulation of Water Trades.

Any market requires reasonably secure water rights to operate. Unfortunately, water rights are weaker than for resources, such as land, both due to its physical characteristics and due to legal restrictions. Because of its physical mobility surface water cannot be bounded or

[6] www.waterstrategist.com

partitioned easily across claimants and uses. Surface water often is in communication with groundwater, which also migrates and is unobserved. There are simultaneous and sequential users of water so that exclusion is difficult, creating numerous interdependencies. Multiple parties can be affected inadvertently in the establishment of water rights and the trade of water.

In western states, individuals do not own water as they might own land. Water is "owned" by the state in trust for its citizens. Individuals hold only usufruct rights to the water, subject to the requirement that the use be beneficial and reasonable and to oversight by the state in monitoring transfers to insure that they are consistent with the public interest.[7] Accordingly, water rights appear to have *less* protection or be more fragile than are most other property rights.[8] Western water rights are based on prior appropriation that dominates in the region and common law riparian claims that operate along with appropriative water rights in parts of California, Nebraska, Oklahoma, Oregon, Washington, North and South Dakota, and Texas.

The appropriative doctrine allows rights holders to withdraw a certain amount of water from its natural course for private beneficial purposes on land remote from the point of diversion.[9] Ownership of water is allocated through the rule of first possession or priority of claim.[10] The maintenance of appropriative rights is based on placing claimed water into beneficial use. Those with the earliest water claims have the highest priority and those with subsequent claims have lower-priority or junior claims. No two parties can have the same priority, so that there is a ladder of rights on a stream, ranging from lowest in priority to highest. This allocative mechanism provides a clear way of ranking competing claimants in assigning rights and in rationing water during times of drought. Because appropriative rights can be

[7] Gould (1995, 94), Simms (1995, 321).
[8] Sax (1990, 260), Gray (1994b, 262), and Koehler (1995, 555). .
[9] Getches (1997, 74-189).
[10] See discussion of first possession in Epstein (1979), Rose (1985), and Lueck (1995, 1998).

separated from the land and sold or leased, they can be the basis for private water transfers in response to changing economic conditions.[11]

Appropriative rights are measured in terms of diversion. The extent of each diversion, however, varies over time due to fluctuating rainfall and snow pack, which affect stream flow and reservoir size. Water diversions can be measured more easily than actual consumption, which is affected by the nature of use and by geologic and hydraulic conditions. Measuring consumption is important because it indicates the amount of diverted water that is released as recharge for subsequent claiming and use by others.

For these reasons, the states regulate water trades that change the location of water diversion, nature of use, and timing, especially if they are large relative to stream flow.[12] Transfers that do not have these effects generally do not require state approval. State water agencies typically allow changes in diversion and location for only historical consumptive uses.[13] Transfers of surface water rights in western states also are predicated on there being "no harm or injury" to downstream rights holders.[14]

III. Water Marketing as Addressed in the Economics Literature.

There is a large economics literature on water reallocation and the potential for water markets to facilitate it, and we can only point to representative articles here. There is acknowledgement of the sharp differences in marginal water values among agricultural, urban, and environmental applications, but at the same time puzzlement regarding the comparatively limited extent of voluntary exchange (Young, 1986). One response has been to focus on the

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[11] Getches (1997, 156-60).
[12] Getches (1997, 168-70).
[13] Anderson and Johnson (1986) and Johnson, et al (1981). Johnson, et al describe how specifying a property right in water in terms of consumptive use with options for third party grievances can be an effective method for promoting transfers.
[14] MacDonnell (1990, Vol. I, p. 11) Can change point of diversion if no harm as with most western states

special characteristics of water that raise the costs of defining and enforcing water rights and that result in pecuniary and technological externalities when water is transferred to a new location. Young and Haveman (1985) and Hanemann (2005) point to the simultaneous and sequential use of water, its mobility and unobservability (groundwater), as well as the variability and uncertainty of its supply. These factors link parties so that any action by one is likely to impact others; increase measurement and bounding costs, making it difficult to clearly assign property rights; and reduce incentive to trade extra water.

Third-party effects from water transfers arise from a number of technological factors. An important source is the hydrological and geological tie between surface and ground water. If farmers sell surface water and turn to greater groundwater withdrawal as a substitute or invest in ditch-lining and other conservation actions, pumping costs, subsidence, and lower water quality (salt water intrusion, for example) can increase for all users of an aquifer (Knapp, Weinberg, Howitt, Posnikoff, 2003). Groundwater is typically a common-pool with complex management requirements (Provencher, 1993; Provencher and Burt, 1993).

Another related technical externality arises from lost return flows when water is shipped out of the watershed. This effect occurs not only with reduced groundwater recharge, but also when downstream surface water is diminished by upstream sales. When a party diverts water from a stream, some of it will be consumed, but much of it (perhaps 50 percent or more) will percolate back to the stream for use by others. When the diverted water is sold, however, this return flow may be blocked. Chang and Griffin (1992) point out that water markets have formed where such effects are small, either due to a limited number of potential third parties or to a unique geography that makes return flow easy to quantify, track, and measure. Johnson, Gisser, and Werner (1981) argue that limiting transfers to consumptive use will limit these downstream effects.[15]

Besides technical externalities, there also can be pecuniary effects if the agricultural economy is diminished from water transfers. Hanak (2003) discusses both pecuniary and technological third party effects in examining county restrictions in California on water transfers. Further, county budgets may be adversely affected as tax bases shrink when municipalities purchase farmland for water and retire the farms from agriculture. Finally, rural political influence may be lost when large water transfers are made, and there is no clear mechanism for compensation. Equity issues are also addressed by (Charney and Woodard, 1990; Howe, Lazo, and Weber, 1990; Howitt, 1994; Howe; Howe and Goemans, 2003).[16] All of these factors raise opposition to greater use of water markets (Haddad, 2000, 33-48).

Because of these third-party effects, however, states have review processes for transfers, as described in the previous section, and this regulation raises transaction costs. Colby (1990, 1189, 1191) finds that transaction costs are particularly high and delays are long in Colorado due to its adversarial water court system, whereas Utah and New Mexico have smoother regulatory systems and lower transaction costs.[17] Howe, Boggs, and Butler (1990, 402) show a wide range of transaction costs from nine case studies of water transfers. They find that transaction costs tend to be smaller when larger amounts are transferred, where there is less opposition, and the higher the priority of the water right.

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[15]See also Livingston and Miller (1986).

[16]See the readings included in National Research Council (1992) and the volume edited by Carter, Vaux, and Scheuring (1994).

[17] Various state regulations regarding transfers are outlined in MacDonnell (1990); Hogge, Hansen, Riley, and Davis (1990) for Utah; Brown, Du Mars, Minnis, Smasal, Kennedy, and Urban (1990) for New Mexico; MacDonnell, Howe, and Rice (1990) for Colorado; Woodard and McCarthy (1990) for Arizona, and Squillace (1990) for Wyoming.

The institutional structure also affects transaction costs. Carey and Sunding (2001) compare the California Central Valley Project with the Colorado Big Thompson Project in Colorado. They find that where there are multiple districts with different regulations and procedures, there are higher transaction costs than in the case where a certain district has a single set of rules and captures all return flows.

Nevertheless, most of the economics literature emphasizes the gains from expanding water trading.[18] Anderson and Snyder (1997) summarize the overall benefits. Howitt (1994) points to the role of the water bank established by California during 1991 in mitigating the effects of drought. Colby, McGinnis, and Rait (1991) examine the use of voluntary exchanges to augment instream flows and improve habitat in the Truckee-Carson drainage of Northern Nevada.[19] Howe, Schurmeier, and Shaw (1986) outline a range of benefits of greater reliance on water markets. With this background, we can now turn to the extent and nature of water trading between the agriculture and urban sectors and within sector trades.

IV. Data Collection Methodology.

We recorded every transfer listed in the *Water Strategist* from January 1987 through December 2005 in twelve western states: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Texas, Utah, Wyoming, and Washington. Two of the most important variables collected were each transfer's beginning and end use. The original use of the water could be classified as agriculture, urban (municipal and industrial), or environmental. Furthermore, each transfer's end use could be classified as agricultural, urban, or environmental.

[18] See the summary of benefits in Haddad (2000, 19-32).
[19] Instream flow rights have particular problems because they require relaxing beneficial use requirements in appropriative water rights and because they are costly to enforce from downstream diversion. See Anderson and Johnson (1986).

This classification system provided for nine possible combinations.[20] For our purposes of examining water reallocation, we are most interested in cross-sector trades, agriculture-to-urban, and within-sector trades, agriculture-to-agriculture and urban-to-urban.

For the majority of transfers the *Water Strategist* explicitly indicated both the original and the ultimate purpose of the water and briefly described the details of each transaction. In cases where the entry did not explicitly state the nature of use of the water before or after the transaction, it often was straightforward to determine the origination and destination uses from the context of the description. For a few transactions where the entry did not include the original and ultimate uses and the transaction description was not informative, we developed rules-of-thumb for classifying these transactions.[21]

According to our rules-of-thumb, we classified a use as agricultural if the name of the lessor, lessee, seller, or buyer, was an irrigator, an irrigation district, an agricultural user, a farmer, a ranch, a canal company, a ditch company or an individual[22]. Similarly, we designated a use as agricultural if the description of the transaction stated that the water was used in agriculture, if the water was provided by land fallowing, or if the description discussed widespread farming in the district from which the water was supplied or sent. In general, irrigation districts and water districts were also classified as agriculture when the *Water Strategist* was unclear.

[20] The nine possible classifications are: agricultural-to-agricultural, agricultural-to-urban, agricultural-to-environmental, urban-to-agricultural, urban-to-urban, urban-to-urban, urban-to-environmental, environmental-to-agricultural, environmental-to-urban, and environmental-to-environmental.

[21] In select cases where the description of the transfer contained in the *Water Strategist* was ambiguous, we relied upon Robert Glennon's knowledge of water institutions in the West. These transfers primarily occurred in Arizona and California and consisted of approximately 55 of the 3,317 transfers in the dataset.

[22] One could potentially argue that an individual should be classified as an urban user instead of an agricultural user. The *Water Strategist* described the seller of water as an individual 88 times and the buyer 9 times. The total water that was transferred when either the buyer or the seller was listed as an individual was 22,467 acre feet. This amount is less than one one-hundredth of a percent of the total water transferred in our dataset. One transfer by an individual accounted for 15,000 acre feet of the 22,467 acre feet transferred.

We classified a party as an environmental user if it was the state's department of fish and wildlife, a water conservation district, or a nature conservancy. If the user's name contained the words or phrases wildlife, flood control, or conservation, then the user was listed as an environmental user. The U.S. Bureau of Reclamation, generally an agricultural water supplier, was classified as an environmental user when it acted to improve or maintain instream flows, to help fish, to preserve water quality levels, or engaged in other similar activities.

Lastly, rules-of-thumb were used to classify urban users when the *Water Strategist* either did not explicitly say what the water was being used for or the description was too vague to determine the water's use. Urban classifications were assigned if the water was being used by cities, townships, municipal water districts, developers, or companies. Moreover, if the water was being used for golf course irrigation, landscape irrigation, or mining the user was classified as an urban user.

Despite our attempts to develop classification rules that would reliably identify transactors, there were some cases where the information was just too incomplete. These "unknown" transfers that lacked a clear origin or destination fortunately were relatively rare, accounting for 85 (2.6%) of the 3,317 transactions in our data set. They are not included in the tables provided below.[23]

Finally, occasionally there were multiple transfers in a single transaction that involved different sectors. For example, an entry might include an irrigator and a city that transferred a combined 10,000 acre-feet of water to another city. In this case, the destination of the transfer is clear and was to an urban use, but the origination came from agriculture and urban. In many instances the description included a breakdown that allowed us to identify the sectors. For example, if the irrigator and city each transferred 5,000 acre-feet, we noted two transactions, one

[23] These unknown transfers account for 798,932 acre-feet of water, about 2.5 percent of the total in our dataset.

of 5,000 acre-feet from agriculture-to-urban and one of 5,000 acre-feet from urban-to-urban. In some cases, however, this information was not provided. We classified such transfers as "combination" transfers because there was either a combination of origins or a combination of destinations. Of the 3,317 transfers in our dataset, 161 (4.9%) were combination transfers.[24]

V. Price Trends: Evidence of Reallocation Pressures.

The *Water Strategist* transaction summaries generally included price data. We converted all prices into dollars per acre-foot of water for comparison. Prices for one-year transactions were straightforward to transform into per acre-foot terms. For example, if 1,000 acre-feet of water were leased for one year for a total price of $100,000, then the per acre-foot price would be $100. Prices for permanent sales, however, required discounting to provide comparable price data.[25] For instance, suppose party A purchased the right to 1,000 acre-feet of water from party B. In this case, party A receives 1,000 acre-feet of water this year, 1,000 acre-feet of water next year, 1,000 acre-feet in the third, and so on for perpetuity. Thus, unlike a one-time transfer, if the right to 1,000 acre-feet of water is transferred permanently, substantially more than 1,000 acre-feet is received by the purchaser. Consequently, it is necessary to discount permanent transfers to get a meaningful and comparable per acre-foot price. The discounting was done in the same spirit as finding the present value of a perpetual bond. If the right to 1,000 acre-feet of water was permanently transferred for a total price of $1 million, then the discounted price per acre-foot would be $200 using a discount rate of 5%. Of the 3,317 transfers in the dataset 2,189 had prices that could be either directly determined or inferred using the discounting

[24] Combination transfers account for 4,939,997 acre-feet, about 15.5 percent of the total in our dataset.
[25] For discounting, we chose a discount rate of 5% to convert the price of a permanent transfer into a meaningful annual per acre-foot value.

mechanism.[26] Of the 2,189 transfers that listed prices, 1,836 were for the three classifications of primary interest: agriculture-to-agriculture, agriculture-to-urban, and urban-to-urban trades.

Table 1 provides price information for cross-sector trades--agriculture-to-urban as well as for within-sector trades--agriculture-to-agriculture and urban-to-urban. All permanent transfers have been discounted into per acre-foot prices using a discount rate of 5%.[27] Cross-sector prices reflect the values of moving water from agriculture, whereas within-sector trades reflect transactions that retain water in current uses, agricultural or urban. We expect that cross-sector prices should be greater than agriculture-to-agriculture prices, reflecting reallocation pressures, and urban-to-urban prices, where the greatest new demand lies, should be higher than agriculture-to-agriculture prices too.

As shown, the annual mean per acre-foot price for agriculture-to-urban transactions of $747 is considerably larger relative to the agriculture-to-agriculture price of $197, and the difference is statistically different.[28] Urban-to-urban exchanges have a mean price of $257 per acre-foot. The mean price of urban-to-urban transfers is statistically significantly different from the mean price of agriculture-to-agriculture exchanges at the 6% significance level. The p-value of the test is 0.06 meaning there is only a six-percent probability that the two means are the same, therefore lending evidence that the two means are different.[29]

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[26] The missing entries were due to cases where the *Water Strategist* did not provide price information or when the entry coupled the sale of land and water into one price and we had no way of disentangling the two and learning the price of the water.

[27] Since our sample covers the years 1987 – 2005, prices had to be converted into real dollars to compare prices across years. All prices where converted into 1987 dollars using the Consumer Price Index – All Urban Consumers Average from the Bureau of Labor Statistics.

[28] We used a difference in means test with unequal variances to statistically compare the mean price of agriculture-to-urban transfers to agricultural-to-agriculture transfers. The null hypothesis is that the two means are the same with the alternative that the two means are different. The p-value from the test was 0.000 suggesting a strong statistical difference between the two means.

[29] The null hypothesis of the above test is that the urban-to-urban mean and the agriculture-to-agriculture mean are the same with the alternative hypothesis that the two means are different. Consequently, the test uses a two-tailed test. We can also test the null hypothesis, using a one-tailed test, that the urban-to-urban mean is the same as the agriculture-to-agriculture mean with the alternative hypothesis that the urban-to-urban mean is higher than the

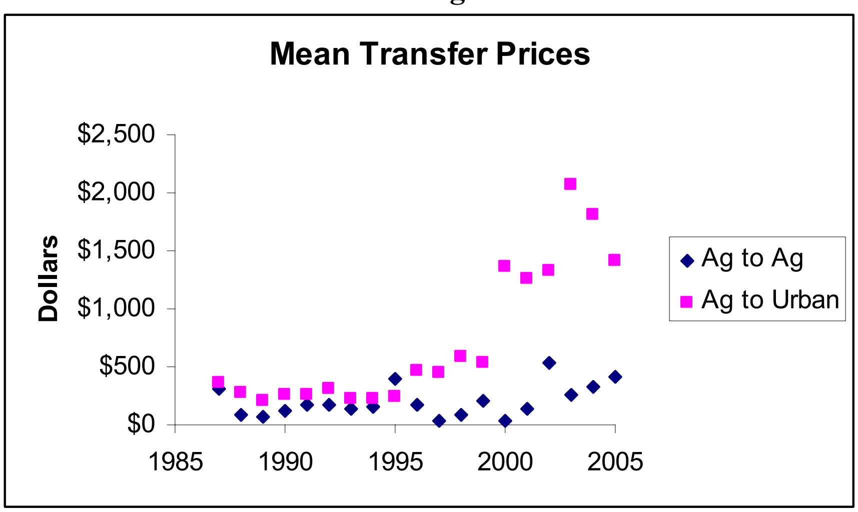
Table 1
Water Transfer Price Differences by Category

Type of Trade	Number of Observations	Mean Price	Std. Err.	95% Confidence Interval	
Agriculture-to-Agriculture	351	$197	$23	$151	$243
Agriculture-to-Urban	1,211	747	23	701	793
Urban-to-Urban	274	257	21	215	299

Source: *Water Strategist.*

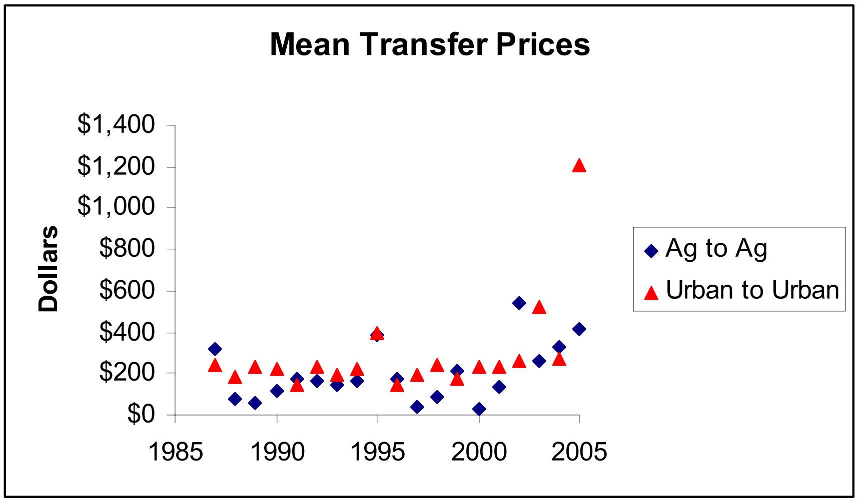
Figure 1 plots mean annual agriculture-to-agriculture against agriculture-to-urban and urban-to-urban prices, respectively from 1987 through 2005. First, not only are prices for urban uses higher than in agriculture on the margin, but the gap between the two is growing as urban demands increase relative to those in agriculture. Secondly, as shown in Figure 2, prices for within-sector trades seem to move together over time, but urban-to-urban prices are generally higher than agriculture-to-agriculture prices reflecting higher marginal values in urban uses.

Figure 1



agriculture-to-agriculture mean. The one tailed test p-value is 0.028. This means that there is approximately a 97% probability that the urban-to-urban mean price is larger than the agriculture-to-agriculture mean price.

Figure 2



VI. Western Water Transfers

Aggregate Transfer Data by Category

Table 2 provides a comprehensive overview of 3,232 water transfers in the 12 western states between 1987 and 2005 from the *Water Strategist*.[30]

Table 2
Western Water Transfers, 1987-2005

Classification	Number of Transfers	Frequency	Amount of Water (af)	Frequency
Agricultural to Agricultural	468	14%	7,132,849	23%
Agricultural to Urban	1,824	56%	5,531,175	18%
Agricultural to Environmental	238	7%	6,025,578	19%
Urban to Agricultural	35	1%	263,690	1%
Urban to Urban	439	14%	5,656,604	18%
Urban to Environmental	60	2%	1,130,102	4%
Environmental to Agricultural	0	0%	0	0%
Environmental to Urban	1	0%	62	0%
Environmental to Environmental	6	0%	284,560	1%
Combination	161	5%	4,939,957	16%
Total	**3,232**	**100%**	**30,964,577**	**100%**

Source: Water Strategist

[30] Less 85 unknown transfers. For more complete discussion of the legal issues involved in water transfers, see Brewer, Glennon, Ker, and Libecap (2006).

Agriculture is the origin of 77 percent of all trades and 60 percent of all water exchanged, evidence consistent with the fact that agriculture accounts for about 80 percent of consumptive use of water in the West. Agriculture-to-urban exchanges are by far the most numerous, accounting for 56 percent of transfers over the period. The amount is also large. Agriculture-to-urban exchanges account for 5,531,175 acre feet or 18 percent of all water transferred. Urban-to-environmental and combination exchanges also account for substantial amounts of water. Urban-to-agriculture, environmental-to-agriculture, environmental-to-urban, and environmental-to-environmental exchanges are relatively unimportant.

As indicated in the table, there is considerable activity within sectors. Agriculture-to-agriculture trades account for 14 percent of the number of transactions and involve 23 percent of all water transferred, the largest single category. Urban-to-urban exchanges, 14 percent of the number of transfers, involve 18 percent of the amount of water traded. If these two major within-sector categories are combined, they account for 28 percent of water trades between 1987 and 2005 and 41 percent of the amount of water. Accordingly, most water that is traded remains within sectors.

Table 3
Transaction Size by Category

Classification	Average Transfer Size (af)
Agricultural to Agricultural	15,241
Agricultural to Urban	3,032
Urban to Urban	12,885

Source: Water Strategist

Table 3 illustrates average transfer size, in acre feet, for within-sector trades and agriculture-to-urban transactions. Agriculture-to agriculture and urban-to-urban transfers are fairly similar in size at about 15,000 and 13,000 acre-feet per transfer, respectively. In contrast, agriculture-to-urban transfers are numerous, as noted in Table 2, but tend to be quite small, averaging only 3,000 acre-feet.

What can we conclude from the data in these two tables? Within-sector trades involve the most water and fairly large individual transactions. Within-sector trades generally retain water in the watershed for similar uses and hence have fewer potential third-party effects on other parties than is the case when water is removed from the area and is no longer available for diversion by others. Many exchanges within irrigation districts, for example, do not require state regulatory review and hence, can proceed routinely.[31] For this reason, the amounts exchanged can be larger. There may be economies of scale in water transfers that can be exploited in these unrestricted transfers that are not possible in cross-sector exchanges. Contention also is less likely in agriculture-to-agriculture and urban-to-urban transfers because these transfers are between fairly homogeneous agents.

On the other hand, out-of-sector exchanges, particularly agriculture-to-urban transactions are more numerous, but comparatively small. These transfers typically involve changes in the location, timing, and nature of water use, all of which can have important effects on other users. These types of exchanges are much more controversial and generally require state regulatory review. Because larger transfers are more likely to affect third parties, agriculture-to-urban exchanges are smaller on average at one-fourth to one-fifth the size of the agriculture-to-agriculture and urban-to-urban exchanges. Smaller transfers likely have fewer external effects.

Contractual Form

More can be learned about the overall water market, as well as about within- and across-sector transactions by examining the type of contract used, short-term, one-year leases, long-term

[31] Irrigation districts are quasi-governmental water supply organizations typically made up of farmers and managed by an elected governing board. For discussion, see Thompson (1993, 687-701).

leases, or sale. Leases involve the temporary transfer of water and not the water right, whereas sales involve the transfer of both the water right and the water.

Table 4
Water Transactions by Contract Type and Category, 1987-2005

		Agriculture-to-Urban	Agriculture-to-Agriculture	Urban-to-Urban
Number of Transfers				
Sale		1,542	213	268
Lease	Short-term	169	222	105
	Long-term	82	17	41
Amount Transferred (af)				
Sale		1,288,847	420,502	604,494
Lease	Short-term	3,329,208	6,353,338	4,301,137
	Long-term	651,646	85,659	626,546
Average Size of Transaction (af)				
Sale		836	1,974	2,256
Lease	Short-term	19,699	28,619	40,963
	Long-term	7,947	5,039	15,282

Note: Short-term leases include "short-term" sales.

Table 4 breaks out transfers by contract type and major category.[32] The data in the table show that most agriculture-to-urban exchanges are through sales that involve comparatively small amounts, 836 acre-feet on average for a total of 1,289,000 acre feet.[33] Sales are used less frequently for agriculture-to-agriculture and urban-to-urban transactions. More water is transferred from agriculture-to-urban use via leases with short-term (one-year) leases involving 3,330,000 acre feet, about five times as much as long-term leases at 650,000 acre feet.

[32] Eighty-six transfers were neither leases nor sales and are not included in Table 4. An example of such a transfer would be an exchange for service between two parties. For example, a developer might give his water right to the city free of charge in return for a service.

[33] The *Water Strategist* sometimes referred to transactions as sales that transferred the water but not necessarily the water right. In our data set these are referred to as short-term sales. Short-term sales can be thought of in a similar manner as a short-term lease. Of the 127 short-term sales that occurred over the 19 years in our dataset, 90 were in California. There were 71 permanent sales in California. The average transfer size for the state of California is 23,159 acre feet, whereas the rest of the West has an average transfer size of only 7,210 acre feet. This implies that 46% of sales in California were permanent sales; contrasted to 98% of sales that were permanent sales in states other than California.

Transaction sizes for one-year exchanges are also large at 19,699 acre feet, more than double the size of long-term leases and 24 times the mean size of each sale. As discussed above, permanent water exchanges from agriculture to urban uses are typically in small allotments in order to pass regulatory review and minimize third-party effects.

Cross-sector, short-term leases can be for larger amounts because they do not imply a permanent loss of water in the watershed. Long-term leases are less common than short-term leases, 82 compared to 169, and are smaller in size. This is understandable because removing water from the watershed potentially has more third-party effects. Of the long-term leases, 17 are five-years or less in length and 65 are more than five-years.

In contrast to cross-sector trades, within-agricultural sector trades are most often (239) through some type of lease, generally for one year. Like cross-sector leases, within-agricultural sector leases are for much larger amounts of water than is the case for water sales. Farmers trade water routinely to meet short-term short falls or for other short-term market reasons using one-year leases. These transactions generally can take place locally or within the irrigation district for which many farmers belong. These short-term exchanges have few third-party effects, and therefore can be large at 28,619 acre feet on average for short-term leases. Sales within agriculture are numerous, but for a generally small amount of water, 420,502 acre feet with a mean transaction size of 1,974 acre feet.

Within-sector, urban-to-urban transfers have more permanent sales (268) than leases (146). But as is the case with the other sectors we have looked at, the average size of sales is small at 2,256 acre-feet compared to the average size of short- and long-term leases at 40,963 and 15,282, respectively. Over four times the amount of water is transferred between cities and from businesses or mining companies by short-term leases than by long-term leases and sales.

Table 5
Water Transactions by Contract Type, 1987-2005

	Length	Number of Transfers	Relative Frequency	Amount Transferred (af)	Relative Frequency
Leases	1-year or Less	788	24%	23,758,304	77%
	More than 1-year	193	6%	2,087,575	6%
	Total:	981	30%	25,845,879	83%
Sales	**Total:**	2,165	67%	3,974,808	13%
Misc.	**Total:**	86	3%	1,143,890	4%
	All Transfers	**3,232**	100%	**30,964,577**	100%

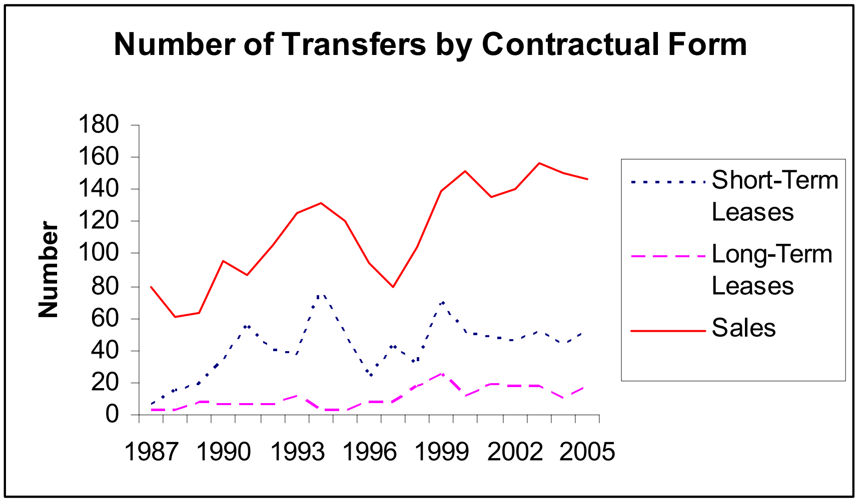
Note: Short-term Sales included with Short-term leases. Miscellaneous transfers are those not designated as either sales or leases in the *Water Strategist.*

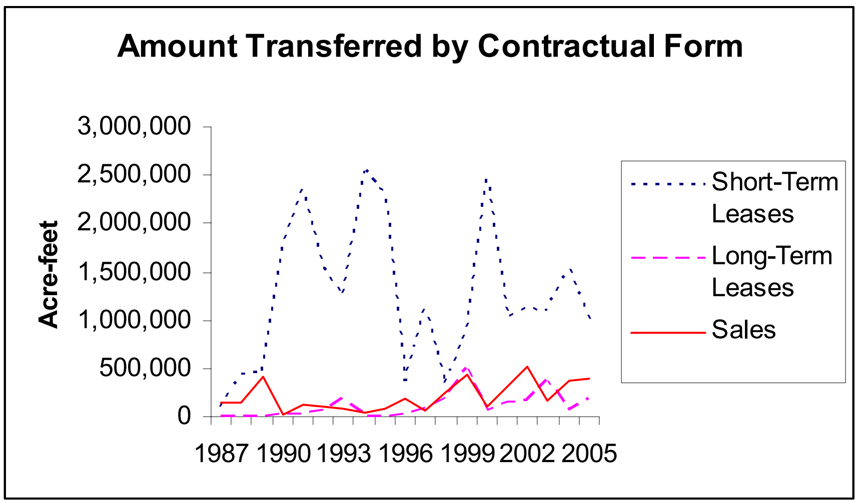
Table 5 summarizes all water transfers from 1987 through 2005 by contract type. Although sales account for 67 percent of all transactions, they involve just 13 percent of the water. Leases are relatively more important, including 30 percent of transactions and 83 percent of all water. Among all transfers short-term leases stand out. They are 24 percent of transactions, but 77 percent of the water traded.

Contract Type over Time

Figure 3 depicts both how the total number of transfers and the amount of water transferred, respectively, moves over time by contractual form. The first graph in Figure 3 shows that sales are generally increasing over time whereas there is no clear trend with either short-term or long-term leases. The second graph displays the acre-feet of water transferred over time. The graph shows that short-term leases systematically account for the most water transferred, but the amounts vary substantially year-to-year.

Figure 3



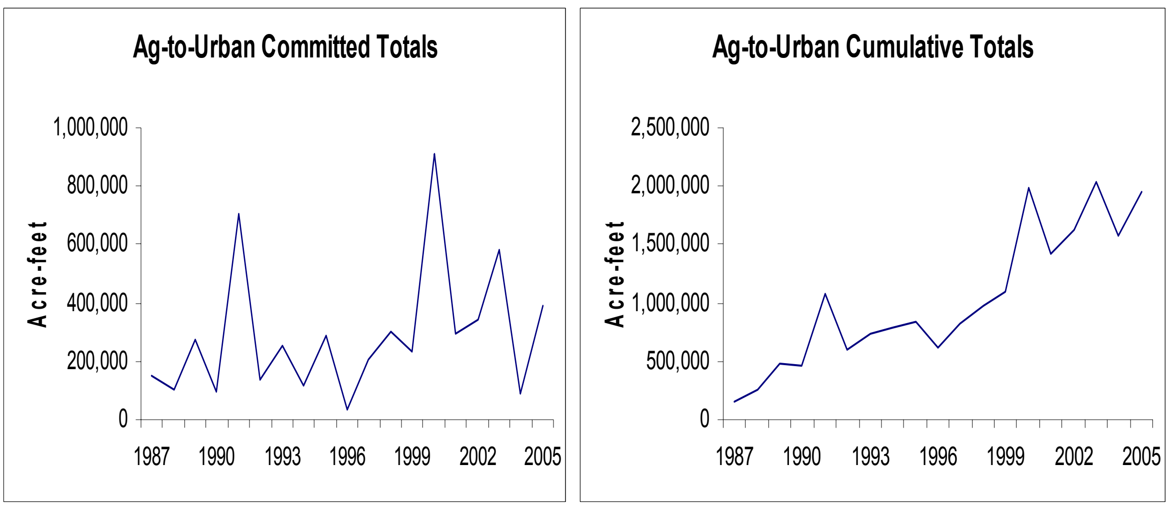


Water Transfers over Time, 1987-2005

An advantage of collecting a time series of data is that it is possible to observe how the water market is changing over time. Both the number of contracts entered into each year and the amounts transferred are important. We refer to the former as "committed" water transaction and the latter as "cumulative" water transfers. For multiple-year contracts, such as party A leased 10,000 acre feet of water to party B for 5 years, a committed transaction is the single agreement to transfer 10,000 feet annually, 1990-95. The amounts of water moved, however, involve five separate transfers, one each year for 10,000 acre feet. Each of these is part of a cumulative transfer. These distinctions are important, especially for individual long-term leases and sales that commit the annual flow of water across time.

Figure 4 illustrates the patterns of water transfers for the 19 years, 1987 to 2005, for agriculture-to-urban transactions using both committed and cumulative measures. As indicated by the graph of committed transfers, the number of contracts to move water from agriculture to urban uses generally is increasing, although the amount of activity fluctuates considerably.

Figure 4



The cumulative graph is smoother and shows that the amount of water transferred is growing over time. Caution is in order, however, because we only have data on transactions that occurred beginning in 1987, and surely water was transferred before then. The committed graph, however, would not change. For this reason, we focus our attention on committed transfers.

Analysis of Water Transfers by State

Table 6				
Share of each Transfer's Classification to a State's Total Transfer Amount (af) within Three Categories				
	Ag to Urban	Ag to Ag	Urban to Urban	Acre-feet

AZ	15%	46%	39%	8,340,905
CA	41%	32%	27%	5,035,890
CO	51%	29%	20%	593,221
ID	39%	55%	6%	1,586,643
MT	55%	45%	0%	23,400
NM	15%	78%	7%	104,577
NV	84%	0%	16%	215,185
OR	0%	100%	0%	100,027
TX	48%	15%	37%	1,752,321
UT	38%	32%	29%	309,934
WA	49%	36%	15%	161,225
WY	37%	63%	0%	97,301

Source: Water Strategist.

Table 6 provides a detailed description of water transfer patterns for agriculture-to-agriculture, agriculture-to-urban, and urban-to-urban transactions within each of the western states. The table shows the relative percentages of the amount of water exchanged by origination and destination classifications. For example within Arizona 15 percent of the water transferred was in agriculture-to-urban trades, while 46 percent and 39 percent were part of agriculture-to-agriculture and urban-to-urban trades.[34] Clearly, in Arizona within-sector trades are by far the most common type of transaction, and more water is traded within the three categories shown in the table than in any other state. This may reflect Arizona's reliance on groundwater and the clustering of agriculture and urban areas near groundwater basins.

California accounts for the next largest amount of water in these categories, and it has a broader range of transactions with agriculture-to-urban trades the largest activity. This reflects the efforts of Los Angeles and the Metropolitan Water District of Southern California in securing agricultural water. Colorado also has a broad range of transactions, also with agriculture-to-urban transactions the most common among these three categories, although the overall amount of water exchanged is smaller than in Arizona or California. Idaho and Texas transfer about the

[34] The residual classification is made up of environmental-to-agricultural, environmental-to-urban, and environmental-to-environmental transfers.

same amount of water, but trades involving urban areas are more prevalent in Texas than in Idaho, reflecting the greater urbanization of the former. The other states trade relatively less water in these categories, and agriculture-to-urban trades are most important in Montana (even though the amount is small), Nevada, Utah, and Washington. Agriculture-to-agriculture trades account for most of the small amount of water traded in Wyoming.

Table 7

Relative Percentage of State to each Classification's Total Transfer Amount

	Ag to Urban	Ag to Ag	Urban to Urban
AZ	23%	0%	53%
CA	38%	46%	23%
CO	5%	4%	2%
ID	11%	37%	12%
MT	0%	1%	0%
NM	0%	2%	1%
NV	3%	1%	0%
OR	0%	7%	1%
TX	15%	0%	4%
UT	2%	0%	1%
WA	1%	1%	1%
WY	1%	0%	1%
Acre-feet	5,531,175	7,132,849	5,656,605

Table 7 provides for cross-state comparison by indicating how much each state contributed to the total amount of water transferred in each of the three classifications. For example, of the total amount of water that was transferred from agricultural uses to urban uses, the state of Arizona transferred 23 percent and California 38 percent. Texas and Idaho are the other major states in agriculture-to-urban transfers. For within-sector trades, Arizona, California, and Idaho move most of the water within agriculture. Arizona, California, and Texas account for most of the water in urban-to-urban trades. Much less water market activity in terms of amounts in these categories occurs in Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

VII. Concluding Remarks:

Relative price data reflect the growing pressure to move water from traditional uses in agriculture to meeting increased urban demand. This paper has presented a new data set that documents the growth of water markets between 1987 and 2005 for 12 western states. Data for the analysis comes from the *Water Strategist*, a monthly publication detailing transactions, litigation, legislation, and other water market activities in the West.

Despite the price trends reported in the paper, we observe that most water moves not from agriculture, but within sectors, from agricultural-to-agricultural use and urban-to-urban use. This pattern may reflect the influence of third-party effects that could occur when water is exported from a watershed, as often occurs with agriculture-to-urban trades. Even so, there is considerable trading of water from agriculture-to-urban areas. Most transactions occur through sales, but most water moves through short-term leases. Indeed, short-term leases account for the largest amounts of water transferred in all three categories. This phenomenon represents the exchange of water to meet short-term conditions, particularly drought, and there has been considerable fluctuation over the 19 years in our data set. Sales, which reflect the transfer of a water right are growing and gradually accounting for greater amounts of water. Finally, there is considerable variation in water marketing across the states. Arizona, California, Colorado, Idaho, and Texas are the most active states in terms of amounts of water traded. In future research, we will report the results of econometric analyses of observed differences in water marketing across the states and across time.

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