

The State of Water Rights and Western U.S. Water Markets

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Introduction

In the United States, especially in the semi-arid West, there is a growing water crisis. A combination of urban population growth, new claims for environmental and recreational water, and concerns over future water availability in light of possible climate change is placing demands on fresh water that are greater than available supplies. In California alone in its 1998 California Water Plan update, the state Department of Water Resources forecast a gap between water supply and demand ranging from 2.4 million acre-feet during normal years up to 6.2 million acre-feet in drought years by 2020. This is a large shortfall. An acre foot of water, 326,000 gallons, can support up to two families per year.¹

There are limited new sources--desalinization is very costly, dams are both costly and controversial, and greater conservation can only yield so much. Accordingly, water must be reallocated from historical agricultural uses, which consume about 80 percent of western water. Property rights and markets are valuable options for this reallocation, and they provide incentives for investment in water and generate valuable information about relative values for wise water use. Even so, water markets are limited and controversial.

In this paper, I present a picture of the current problems; provide a description of the nature of water rights; outline the pattern of trades within water markets; and conclude with recommendations for ways to move forward.

I. A Misallocation of Water

Currently, we use a great deal of water to grow heavily subsidized cotton and alfalfa feed.² Irrigation systems may lose 40 to 50 percent of the water diverted into them through seepage. Once the water reaches a farm, many farmers use highly inefficient flood irrigation or sprinkler systems that direct water into the air where much of it evaporates, or they apply it to low-valued uses because of the beneficial use requirement that mandates that each irrigator use all of the water or lose it. Further, in California's Imperial Valley, almost one million acre-feet of the three million acre-feet diverted by the Imperial Irrigation District from the Colorado River (the largest single user of the river's water) ends up as wastewater flowing into the saline Salton Sea. Under the doctrine of salvage, a farmer who conserves water may lose the right to it.

At the same time, there are many more valuable uses for the water. In California, an acre-foot used in the semiconductor industry produces \$980,000 in gross state

¹ <http://www.mongabay.com/reference/environment2/Acre-foot.html>

² Drawn from Jedidiah Brewer, Robert Glennon, Alan Ker, and Gary D. Libecap, 2007, "Transferring Water in the American West: 1987-2005," *Michigan Journal of Law Reform*, 40 (4): 1021-1053.

revenue; that same acre-foot used to grow cotton and alfalfa generates \$60.³ The value to and the price paid by municipal and industrial users dwarfs that paid by farmers. For instance, groundwater for farming near Marana, Pima County, Arizona costs approximately \$25 per acre-foot, whereas the same water for urban use costs \$700. 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 for the same Colorado River water.⁴

Such disparities of value underscore the importance of reallocating water from low-value to higher-value activities through water markets. Further, climate change predictions are worrisome for supplies. Based on predicted trends for California, the amount of water stored in the Sierras as snow pack (the state's chief source of fresh water) may decline by 30 to 70 percent over the next 50 years.⁵

Accordingly, there is a critical need to examine ways to promote the efficient reallocation of water, and water rights and water markets can play an important role in this effort. There is opposition, however, to viewing water as a commodity and associated the private ownership of water. For example, consider the book, *Bottlemania, How Water Went on Sale and Why we Bought It*, by Elizabeth Royte, reviewed on the front page of the *New York Times Book Review*, June 15, 2008.⁶ The author not only is opposed to commercial bottled water, but to the whole notion of privatization. Other skeptics include Marc Reisner in *Cadillac Desert: The American West and Its Disappearing Water* and Alan Snitow, Deborah Kaufman and Michael Fox in *Thirst: Fighting the Corporate Theft of Our Water*, who emphasize the principle that water is a basic human right and therefore is inherently public.⁷ Unfortunately, for the very reasons that these authors stress, water is too important to be left solely to often inflexible and unresponsive bureaucratic rules and to the short time horizons of many politicians.

Indeed, the evidence of government provision and regulation of natural resources is not encouraging. After decades of regulation and/or ownership, the nation's fisheries have been overfished, forests overharvested, and rangelands overgrazed. Further, the

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

⁴ See Glennon, 2002, *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters*, Washington D.C.: Island Press.

⁵ February 2004 study by L. Ruby Leung at the U.S. Department of Energy's Pacific Northwest National Laboratory.

⁶ Elizabeth Royte, 2008, *Bottlemania: How Water Went on Sale and Why We Bought It*, New York: Bloomsbury.

⁷ Marc Reisner, 1993, *Cadillac Desert: The American West and Its Disappearing Water*, New York: Penguin Books, Revised Edition; Alan Snitow, Deborah Kaufman, and Michael Fox, 2007, *Thirst: Fighting the Corporate Theft of Our Water*, San Francisco: Jossey-Bass/Wiley and Sons.

regulatory regime has provided few incentives for meaningful investment in the resource stock. Importantly, under public ownership and management, no party (politician, agency official, or resource user) is a direct residual claimant to the benefits and costs of efficient use and investment decisions. Accordingly, there is little likelihood that those decisions will be consistent with maximizing the economic and/or social value of the resource. Fresh water is too precious to be relegated to such conditions.

For these reasons, across a variety of resources there is a movement away from command and control regulation and toward markets. A recent survey found that tradable use permits (a type of property right) were used in 9 applications in air pollution control, 75 in fisheries, 3 in water, and 5 in land use control.⁸ These institutional innovations have taken place as the resources have become more valuable and as dissatisfaction has increased with existing centralized regulation.⁹

II. The Advantage of Water Markets

There are multiple advantages of property rights and market arrangements for all natural resources, including water. These range from flexibility, cost-savings, information generation, migration to high-valued uses, and better alignment of incentives for conservation or investment in the resource. The more complete are property rights, the more the private and social net benefits of resource use are meshed, eliminating externalities and the losses of the common pool.¹⁰

A key advantage of markets is that the sale or other exchange of property rights releases valuable information regarding alternative uses and opportunity costs that promote efficiency in resource allocation and application. This is especially important for water, where in the past there has been little information to guide its wise use.

With markets would-be purchasers must determine how much water they want to buy and how much they are willing to pay for it. Sellers have to decide the value of their water. If the offer matches these values, some trade occurs. If it does not, then the buyer has to recalculate willingness to pay, give up the purchase, or wait until a later time when conditions may have changed. Or the seller has to reassess how much the water is worth in current applications relative to the opportunity to sell or lease some water.

With such information, farmers can determine how much water to devote to crops; how much to release to organizations like the Oregon Water Trust for instream flows to protect aquatic habitat; and how much to sell to thirsty cities like Phoenix, Las Vegas, and San Diego. The opportunity to sell or lease water encourages conservation and investment in improved irrigation techniques and shifts toward less water-intensive

⁸ Tom Tietenberg, 2007, "Tradable Permits in Principle and Practice," in Jody Freeman and Charles D. Kolstad, eds, *Moving to Markets in Environmental Regulation*, New York: Oxford University Press, 63-94, 69.

⁹ Robert N. Stavins, 1998, "Economic Incentives for Environmental Regulation," 1998b, *The New Palgrave Dictionary of Economics and the Law*, MacMillan, London, Peter Newman Ed., Vol. 2: 6-13.

¹⁰ Gary D. Libecap, 1989, *Contracting for Property Rights*, New York: Cambridge University Press; Carl Dahlman, 1979, "The Problem of Externality," *The Journal of Law and Economics* 22: 141-62.

crops. At the same time, clear price signals tell environmental and recreation groups as well as city water companies how much they must pay to acquire water. This information also encourages conservation and moderation in demand. In this way, water flows to high-valued uses and thereby maximizes social benefits.

Another well-known advantage of a water market is that it recognizes existing property rights as a basis for exchange. There is a legal framework for bargaining among the parties to redistribute water. There is a recognized owner and a potential buyer. They may agree or disagree at any point in time. The structure elicits negotiation and cooperation, and provides for routine, timely redistribution as values change. It reduces social conflict and division because in voluntary trade both parties benefit. Such a framework is critical because variability in supply due to periodic drought requires flexible exchange mechanisms.

A final and related advantage of a market approach and secure property rights is that they encourage investment in water conservation, storage, allocation, and quality. Surely, given the semi-arid nature of the West, it is in society's interest to promote these investments. These ventures not only include those for urban supply infrastructure, but also for improvements in fish habitat and stream conditions.

For markets to work, however, property rights must be clear and respected. Most economists agree that an efficient system of property rights requires three elements: A complete definition; exclusivity; and transferability. Yet, water markets appear to be developing more slowly than the price gaps described above would suggest. To better understand the state of water markets, I now turn to the nature of water and water rights, the many parties involved in water decisions, and finally to evidence on water trades.

III. The Problem of Water

The Peculiarities of Water that affect Property Rights Definition

As a mobile resource, water is not easily bounded. Unlike property in land, for example, rights to water are not allocated to claimants in partitioned stocks. Water's mobility does not allow for it to be easily excluded from other potential users. Water in rivers and streams often travels hundreds of miles and crosses many private and public boundaries. Surface water is also susceptible to evaporation and seepage into groundwater. Lakes and reservoirs are less affected by water mobility. Still, they are not easily partitioned into parcels.¹¹ Making a claim to water, therefore, cannot be done in the traditional manner of capturing and bounding a resource, such as land. The costs of defining and enforcing property rights in water are unique and typically much greater.

In the American West, surface water rights are assigned to flows of water. The standard unit of measurement is acre-feet per year, 325,851 gallons. The precision of this measure, however, fails to convey the complexity of measuring water allocations and use. A key issue is the distinction is between the quantity of water diverted and the quantity

¹¹ This discussion is drawn from Zachary Donohew, forthcoming, "Property Rights and Western U.S. Water Markets" *Australian Journal of Agricultural and Resource Economics* and from Jedidiah Brewer, Robert Glennon, Alan Ker and Gary Libecap, 2008, "Water Markets in the West: Prices, Trading, and Contractual Forms," *Economic Inquiry* 46 (2): 91-112.

consumed. In agriculture, for example, the amount of water diverted is the amount removed from a stream and used in the production of crops or livestock. The diversion amount is observable and therefore not difficult to measure. Seasonality and drought, however, can affect the amount of water that is available for diversion and increase uncertainty. In water markets it may be difficult to forecast whether a water source will be able to fulfill a water commitment, and this situation requires use of water delivery options or other more complex contracts.

Consumption, however, is more difficult to measure than is diversion. It is affected by the type of crops grown, evaporation, topography, geology, and hydrology. Especially in agriculture, the amount of water consumed is often much less than the amount diverted. Crops typically absorb only a portion of the water and other amounts seep into the soil. At least part of the unconsumed portion of diverted water percolates back to the stream for use by other water claimants. Depending on the use, in some areas up to 50 percent of water diversions can be recaptured, so that downstream water claimants may depend critically on the timing and nature of upstream water diversions. Indeed, for many transactions only consumptive use is traded, leaving the rest of the diversion available for others who depend on return flows. For these reasons, it is important to measure consumptive use effectively.

Because of the links between sequential water claimants, most western states require that all water trades that involve changes in the timing, location or use of water be subject to regulatory review. To guard against a reduction in water availability and quality, surface water rights are both protected and constrained by “no injury” rules. As the phrase suggests, no injury rules guard against third-party effects of water transactions. To gain regulatory approval, those planning to sell or lease water out of a watershed must demonstrate that other claimants will not be adversely affected. Each of the states has a different review process and some impose more transaction costs than do others.

For all of these reasons, defining and enforcing property rights in water is more difficult than in land. Besides the interdependencies across surface water claimants, there are also linkages between surface and subsurface water. Transactions that move surface water out of a region can reduce the water that is available to replenish aquifers and hence, harm those who rely on ground water.

Despite all of this, water rights can be defined and water markets can be a major vehicle for water reallocation. Markets evolve and allocate resources in many other complicated situations successfully.

Water Rights

Appropriative Water Rights. In the U.S. there are two major types of water rights, appropriative water rights found in the West, and riparian water rights, found in the East. Prior appropriation was adopted first in the western United States in the 1850s by miners who appropriated surface water for sluicing. Appropriative water rights grant diversion privileges, generally to stream flow, in the order of claiming so that the earliest claimant has the highest priority. As indicated earlier, all water assigned must be used under the beneficial use doctrine. Any remaining water is freed for subsequent claimants. Under the prior appropriation doctrine, there is a ladder of water rights on each stream that range

from highest to lowest priority, and the highest priority claim gets first access to the water. Relative to junior priority rights, then, senior water right holders are more certain to receive water delivery, are more valuable, and thus provide more incentive to invest in water infrastructure.

Agricultural users have typically held the more senior water rights; irrigators having outlasted mining interests and entered the western United States before significant population centers and environmental interests began appropriating water rights. This historical allocation is the basis for water reallocation today.

Importantly, appropriative water rights holders in the western U.S. possess only *usufruct* rights; states retain title. This legal arrangement reflects the special role of water in semi arid regions, but it potentially weakens water rights by making them less secure through political and judicial intervention. I address this issue in more detail below.

Appropriative rights holders can lose a water right several ways, including through waste and forfeiture. Willfully wasting water is usually defined as diverting water beyond what is considered reasonable and beneficial. Water lost to irrigation canal seepage or evaporation is not considered wasteful if it is consistent with customs of the locality. Historically, conserved water was not retained by the owner; hence, reducing incentives for investment in water conservation.

Recently, most western states have enacted legislation to grant at least some of the conserved water to the water rights owner. Forfeiture rules apply when water is not placed in beneficial use. The number of years of consecutive non-use varies by state. In Colorado water rights may be cancelled after 10 years of non-use; in Oregon five consecutive years is enough to assume forfeiture. The beneficial use requirement, noted above, has encouraged rights holders to place all water into some application, even very low-valued ones, such as flooding pastures and placing marginal agricultural areas into cultivation. This water, however, provides the greatest opportunity for reallocation via water markets. Much of the water that could be traded from agriculture to urban and environmental uses is likely to have little economic impact on agricultural areas because it will come from low-return activities.

The well-developed appropriative water rights doctrine in the U.S. west is the basis for water markets. The doctrine allows for water to be claimed, diverted, and separated from the land through which the water flows. It can be transported out of basin for use elsewhere. As such, those who buy water rights or lease water can change the location of diversion, timing of use, and nature and site of ultimate use, subject to regulatory approval to protect downstream claimants.

Riparian Water Rights. This is the other major type of water right found in the U.S. In the eastern part of the United States, which generally has more precipitation, rivers, and other water sources, the riparian system dominates. There has been less need to divert water from water sources for use elsewhere. Like appropriative water rights, riparian rights are usufruct rights; however, riparian rights run appurtenant to the land adjacent to a surface water source. Riparian land owners can access water for a “reasonable use,” so long as downstream users are not adversely affected. Unlike

appropriative rights, riparian rights cannot be forfeited from non-use and they are not assigned priority dates. In times of drought, all riparian users share in the reduced water availability.

The Many Parties Who Have A Decision Making Role in Water Transfers

As described above, water rights are limited relative to those for land because of the physical nature of water and because claimants have only use rights, subject to state oversight. They also are weaker because so many parties can have a say in how water is used or transferred. For these reasons, any water transaction requires approval of multiple bodies—the irrigation district, the state regulatory body, the Bureau of Reclamation. This situation naturally adds complexity to water trading.

State Agencies. Water agencies are the main regulatory bodies charged with administering state water laws. Authority is vested in the State Engineer in New Mexico and Utah, the State Water Resources Control Board in California, or the Department of Water Resources in Oregon and Arizona to name a few agencies. These agencies monitor stream flow to ensure instream quantity requirements are met, enforce water rights by issuing orders to junior water right holders to curtail diversion when water availability is over-appropriated, and approve water right transactions.

The role of the state agency in water transactions is to review the application to ensure that third-parties will not be injured and that the change in use, time, or place does not “enlarge” the water right. These agencies also enforce laws that specify when applications are consistent with the beneficial use doctrine. For example, it was not until 20 years ago that western states began recognizing instream flows as a beneficial use.

Bureau of Reclamation. The largest wholesale provider of water in the United States is the Bureau of Reclamation. Established through the Federal Reclamation Act of 1902 to promote westward expansion and agriculture, the Bureau operates 348 reservoirs in the 17 western states and also maintains canals and hydroelectric power plants. The Bureau most often delivers water through “retailing” institutions such as mutual water companies and irrigation districts. Typically, the water rights are held by the Bureau and contracted to the water districts. Transferring Bureau water entitlements by water districts is allowed; however, Bureau policies have not always been consistent, and transfers usually require approval by the agency.

Water Supply Organizations. There are over 1,000 Irrigation Districts, Mutual Ditch Companies, Conservation Districts, and Water Companies in the western United States. Typically, these organizations act in a trust capacity on behalf of their members, generally farmers; however, their governance styles and voting rules vary greatly. Irrigation districts are the most common type of water supply organization. In most irrigation districts, the water rights are held by the district and then contracted amounts are delivered to members. For all users then, the priority of the water right is the same and allocation based on an agreed-upon mechanism.

Selling and leasing water rights outside an irrigation district usually requires approval from the district board and is met often with opposition, depending on whether

the board is popularly elected by all voters in the district's jurisdiction or elected solely by land owners.

The Regulatory Process

Water rights are also constrained by regulation. A water right is certified only for a particular place of use, point of diversion, and type of use. To change any of these restrictions requires that the governing agency approve the transfer. These transfer rules typically hold for both temporary and permanent water transfers, although they are much stricter for rights sales and long-term leases. Short-term leases may take place within irrigation districts, for example, without regulatory approval because there are few externalities.

An applicant must submit an application to the governing agency describing the proposed change in the current water right. In some states, the applicant may have to hire a certified water rights examiner to study the water use and file a report with the agency detailing the current water use. The agency must then determine that no other water right will be injured by the proposed change, and they will also study whether the change will negatively affect fish, wildlife and other instream users. As noted above, the no injury requirement typically means that a water transfer is limited to the historical consumptive use of the right. This is an important point because any portion of the water right that is not transferred to the new use may be lost and reverted back to the state.

A public announcement of the proposed trade is made, usually printed one or more weeks in a newspaper, and a comment period is opened to allow the public to raise objections to the transfer if they believe a water right will be injured. If the transfer is protested, a hearing is held by the agency or a water court and both sides present their cases. If there is potential injury, the agency or court accept or deny the application, or may attach conditions, such as a reduction in the total water transferred, to an approval order to eliminate injury to other water rights. If a transfer is approved, then the agency will issue a new water right certificate reflecting the permanent change in water use.

Depending on the criteria required for status, the range of grounds for contesting a transfer, and the information requirements that are placed upon the protester, which vary by state, the application process can take well over a year to complete in some cases. In circumstances where a transfer of water is temporary (not a sale of the right), which is most commonly a lease, approval times may be shorter because other water rights are not in jeopardy. Temporary water right transfers can be further limited in the types of transfers allowed. Some states restrict temporary transfers to place of use and point of diversion; not permitting changes in the type of use, such as from agriculture to urban uses. Temporary transfers are often restricted in duration as well.

With this discussion of western water rights, water supply organizations, and the regulatory process in mind (all of which affect water markets), it is now possible to examine the extent and nature of water markets.

IV. The Extent of Water Markets

For all of the reasons we have seen, water rights and markets are more difficult to

assemble than are rights to land. Even so, with dramatic differences in water values pressures for water exchanges are growing.

To get a sense of the nature of water market transactions Brewer, et al (2008) assembled a data set on all water market activities in the 12 western states (Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Texas, Utah, Wyoming, and Washington) from 1987-2005 from the *Water Strategist*.¹² The *Water Strategist* is a monthly trade publication that reports on western water market activity, state and federal legislation, and litigation. Each month, the journal publishes a section titled “Transactions” that reports on sales, leases and exchanges of water rights. The transactions are listed by state and report some or all of the following information: buyer and seller; contract type, such as sale, lease or exchange; quantity of water transferred; water use, such as municipal, agricultural or environmental; and price. Zachary Donohew has extended the data set through 2007.¹³

The dataset spans a 21-year period from 1987-2007 and includes 3,387 observations. This is the most comprehensive data available on water markets across the western United States.

Water Prices

Table 1 describes prices for water transfers by sector and contract type. To compare prices across the 21-year period, all price data are converted to 1987 dollars. Mean and median prices are given in dollars per acre-foot for agriculture-to-agriculture, agriculture-to-environment, agriculture-to-urban, and urban-to-urban trades. These sectors represent 89 percent of 2,530 transactions that include price data. Lease prices are reported in terms of annual flows per year. Sales, on the other hand, represent perpetual right an annual flow of water, as reflected in the higher prices they command.

As shown in the table, the mean and median lease prices for agriculture-to-agriculture transfers are significantly lower than are those for the other trading sectors. This indicates the relatively lower value of water in agriculture at the margin as compared to uses elsewhere and the motivation for water trading.

Table 1

Water Transfer Prices per Acre-Foot 1987-2007							
	Leases				Sales		
	Agriculture-to-Agriculture	Agriculture-to-Environment	Agriculture-to-Urban	Urban-to-Urban	Agriculture-to-Agriculture	Agriculture-to-Environment	Agri to-U
Mean Price (\$)	36	126	424	279	2,362	2,565	4,552

¹² Brewer, Glennon, Ker, and Libecap (2008).

¹³ Donohew, forthcoming. The data set is available at http://www.bren.ucsb.edu/news/water_transfers.htm

Median Price (\$)	11	32	56	123	1,451	552	2,896
Number of Transfers	206	184	207	119	196	52	1097

Source: Brewer, et al, (2008); *Water Strategist*

To further illustrate different price trends, Figure 1 represents the annual median sales prices per acre foot for agriculture-to-agriculture and agriculture-to-urban sector water transfers. Sales data are importantly affected by transactions in one state, Colorado, where the structure of the Colorado Big-Thompson Project makes transfers much easier. Even so, the patterns are clear. Water generally is more valuable in urban uses.

Figure 1

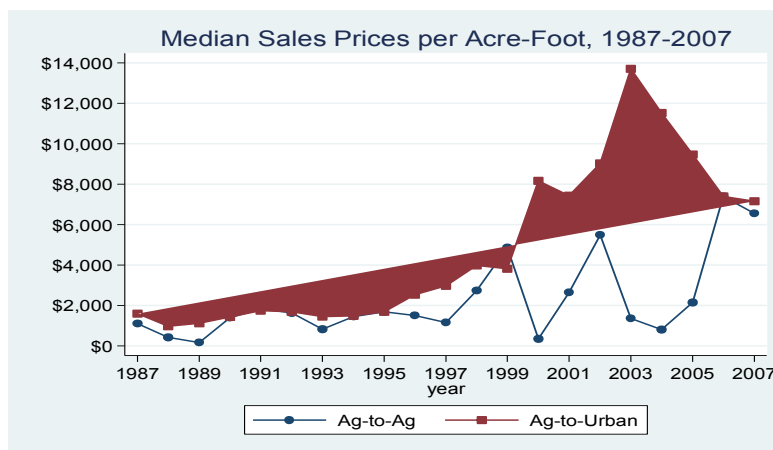
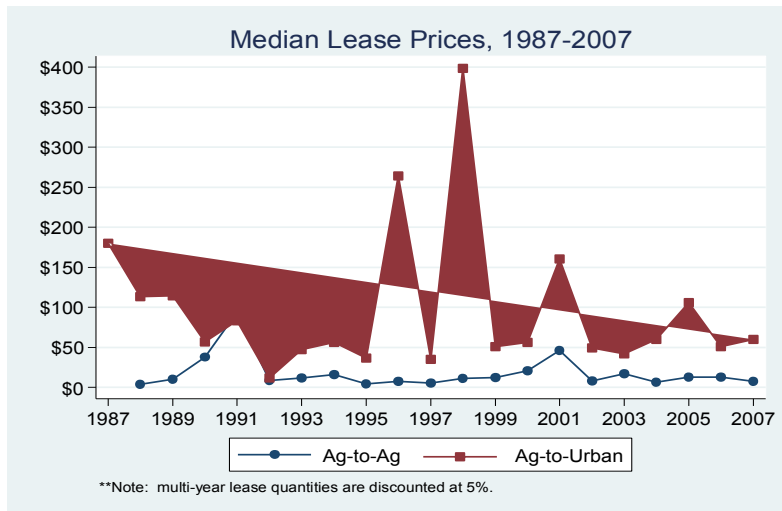


Figure 2 shows the median lease prices from 1987-2007 for agriculture-to-agriculture and agriculture-to-urban sector trades. As with the median sales prices, agriculture-to-urban lease prices are significantly higher than agriculture-to-agriculture lease prices.

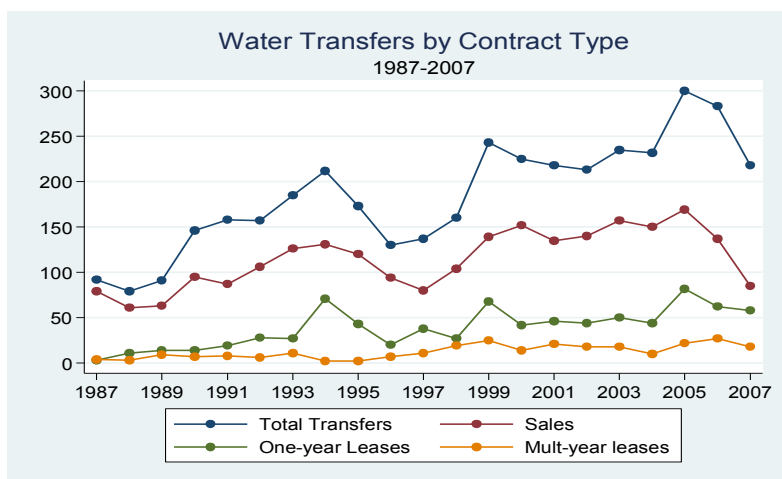
Figure 2



Water Contracts

Additional information about the nature of water markets is gleaned by examining the types of transactions that take place. There are several types of contractual forms available for trading water: sales, short-term and long-term leases. Figure 3 plots the most common contract types over time; breaking down leases to one-year and multi-year. As shown, over time, the total number of annual transactions is trending upward, as are sales and multi-year leases. One-year leases have a nonsignificant trend. These patterns reflect demands to permanently reallocate water across uses. One-year leases generally are used within sectors, among farmers for instance, to adjust temporary water requirements.

Figure 3



Sector Activity

Table 2 describes water transactions by contract type and the most common sector-to-sector trades. The average quantity of water traded is broken down into two distinct measurements: the annual flow and the committed flow of water. The annual flow measurement is the traditional way of defining the volume of water traded. It

describes the amount of water transferred in any one year of a transaction. The downside to this measurement is that it substantially underreports the total amount of water transferred in sales and multi-year leases. Following Brewer et al (2008), a measurement for the committed water flow is reported. The committed variable overcomes the underreporting problem by projecting the annual flow forward for the duration of the lease or, in the case of sales, in perpetuity. The committed variable is calculated by discounting the annual flow by 5 percent per year and then summing the series of years. The resulting measurement is the amount of water committed for the duration of a transaction.

Source: Brewer, et. al (2008); *Water Strategist*

Table 2								
Water Transactions by Contract Type and Sector, 1987-2007								
	Agriculture-to-Urban	Agriculture-to-Agriculture	Urban-to-Urban	Agriculture-to-Environment	Agriculture-to-Urban	Agriculture-to-Agriculture	Urban-to-Urban	Agriculture-to-Environment
	Number of Transfers				Number of Transfers			
Sales	1,667	248	304	85	1,667	248	304	85
Leases								
One-year	154	205	96	174	154	205	96	174
Multi-year	97	28	58	44	97	28	58	44
	Committed Average Size (acre-foot)				Annual Flow Average Size (acre-foot)			
Sales	19,744	34,942	41,731	119,448	987	1,747	2,186	5,893
Leases								
One-year	16,910	28,833	43,482	32,005	16,910	28,833	43,482	32,005
Multi-year	91,701	36,433	212,115	69,741	7,601	3,308	14,364	10,043

The data in Table 2 indicate that agriculture-to-urban sales (1,667) are the most common market transfers. Relative to the other categories, agriculture-to-urban sales are also less in size in terms of flows. These transactions are likely smaller because they change the water use and therefore have to meet regulatory requirements that protect

against third-party injury. They also reflect the many small sales transactions within the Colorado Big-Thompson Project.

Agriculture-to-Environment sales (35) were fewer in number than all other sectors, but they were also much larger in terms of flow than all other sales. These often are in response to court mandates. One-year leases are the most numerous of agriculture-to-environmental sector transfers (174), usually implemented to meet seasonal flow requirements to protect fish stocks.

Agriculture-to-agriculture transactions are split evenly between sales and leases, at 248 and 232, respectively. Sales are small with an average annual flow of 1,747 acre-feet; however, committed flows are much larger at 34,942 acre-feet. Across all sectors multi-year leases are fewer in number than sales or one-year leases. The data in the table reveal a vibrant water market both within and across sectors

V. Conclusion: The State of Water Markets

There are important reasons for moving water from historical agricultural uses to meet new demands for urban and agricultural uses. Water rights and water markets are a major way of promoting this exchange in a low-cost and timely fashion. As described here, water markets will always be somewhat more complex than are those for land. In part this reflects the unique physical properties of water that make it difficult to measure, capture, and trade. Additionally, because of simultaneous and sequential uses of water, there is a role for regulatory oversight to protect other users from any inadvertent effects of trades that change the timing, nature, and location of water use. Finally due to past institutional developments, there are many parties to any water transfer that moves the water out of the drainage area.

Beyond these factors, because water rights are only usufruct rights, they are vulnerable to more active intervention by those who reject private ownership. The extension of the Public Trust Doctrine in the California Supreme Court's famous 1983 ruling in *National Audubon Society v. Superior Court* (33 Cal 3d 419) is such an example. In that ruling the court held that Los Angeles' water rights in the Mono Lake Basin of California were to be limited by the state in order to protect public trust values. This vague criteria set up a 20-year battle that ultimately led to the uncompensated loss of the city's water.¹⁴

For all of these reasons, the activity in water markets described in the previous section remains surprisingly limited. Currently, only about 2 percent of annual water use is traded (at least as measured). Accordingly, there are opportunities to expand the role of markets by more clearly defining the regulatory review process; by constraining the number of decision makers involved in each transaction, and by supporting the clear assignment of private water rights. To meet a growing water crisis water markets are an ideal mechanism for facilitating the socially-valuable movement of water across many competing demands.

¹⁴ See Gary D. Libecap, 2007, *Owens Valley Revisited: A Reassessment of the West's First Great Water Transfer*, Palo Alto: Stanford University Press, Chapters 7 and 8.