Water Rights and Markets in the U.S. Semi-Arid West: Efficiency and Equity Issues

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Abstract

There are both high resource and political costs in defining and enforcing property rights to water and in managing it with markets. In this paper, I examine these issues in the semi-arid U.S. West where many of the intensifying demand and supply problems regarding fresh water are playing out. I begin by illustrating the current state of water markets in 12 western U.S. states. There are major differences in water prices across uses (agriculture, urban, environmental) and these differences appear to persist, suggesting that water markets have not developed fully enough to narrow the gaps. Moreover, there is considerable difference in the extent and nature of water trading across the western states, suggesting that water values and transaction costs of trade vary considerably across jurisdictions. I then turn to the resource and political costs of defining water rights and expanding the use of markets. In this discussion, efficiency and equity objectives play important, often conflicting, roles. This tension reflects the very social nature of the water resource. To understand the problems of expanding water markets, it is critical to understand the varying political, bureaucratic, and administrative incentives involved.

Introduction

There is growing concern about the availability of fresh water worldwide, as demand grows and as supplies become more uncertain due to the potential effects of climate change. With rising per capita incomes and growing populations, human consumption of water is rising, just as demands for water for agriculture, recreation, and environmental habitats are increasing.[1] At the same time, climate change is predicted to make precipitation more variable with the possibility of longer drought periods (Barnett et al., 2008; World Water Assessment Program, 2009). As water values rise due to increased demand and limited supply, one might expect that formal property rights to water would be made more precise and that water markets would become active to more effectively address allocation, management, and conservation pressures.

[1] The *Economist* (April 8, 2009, 52) speculates that no more than 20 per cent of the available water can be 'safely' withdrawn by humans on an on-going basis without having a negative impact on the natural environment (http://www.economist.com/world/international/displaystory.cfm?story_id=13447271).

A process of property rights development and market activity as asset values exogenously rise was described by Harold Demsetz in his classic 1967 paper. Indeed, institutional arrangements for many resources, such as hard rock minerals and oil and gas reservoirs in the U.S., developed in a manner consistent with the Demsetz hypothesis (Libecap, 1978, 2007; Libecap and Smith, 2002). Further in a broader context, commodity markets adjust rapidly to price differentials and reallocate the assets so that price gaps narrow over time. As we will see, however, this process of property rights formation and price convergence is not happening as quickly for fresh water in the western U.S. (Young, 1986, Brewer, et al, 2008).

There are both high resource and political costs in defining and enforcing property rights to water and in managing it with markets. In this paper, I examine these issues in the semi-arid U.S. West where many of the intensifying demand and supply problems regarding fresh water are playing out. To understand the problems of expanding water markets, it is critical to understand the varying political, bureaucratic, and administrative incentives involved.

I begin by illustrating the current state of water markets in 12 western U.S. states.[2] We will see that there are major differences in water prices across uses (agriculture, urban, environmental) and that these differences appear to persist beyond what can be explained by differences in conveyance costs and water quality, suggesting that water markets have not developed fully enough to narrow the gaps. Moreover, there is considerable difference in the extent and nature of water trading across the western states, suggesting that water values and transaction costs of trade vary considerably. I then turn to the resource and political costs of defining water rights and the use of markets. In this discussion, efficiency and equity issues play

[2] The states include California, Washington, Oregon, Idaho, Montana, Wyoming, Nevada, Arizona, New Mexico, Utah, Colorado, and Texas.

important, often conflicting, roles. This tension reflects the very social nature of the water resource.

Efficiency: The Extent of Water Trading

Water Price Differentials

Contemporary western water markets generally are local with trading confined within water basins and sectors (among adjacent irrigators, for example). Typically, exchange outside of a water basin is limited, and voluntary private transactions to move water from agriculture to urban use often is very costly, and in some cases, extremely contentious. And there is virtually no private water trading across state boundaries.

Price differences across uses illustrate the opportunity for exchange, but they are difficult to assemble because of segmented markets, limited comparable observations of trades within and across sectors, high shipping or conveyance costs, diverse regulatory regimes, and variation in water quality. Accordingly, examining available price data must be done with caution, but the patterns are indicative of the thinness of many water markets and of the efficiency gains from further re-allocation.[3]

Data assembled by Clay Landry and reported in Libecap (2011) for two regional markets, the Reno/Truckee Basin, Nevada and the South Platte Basin, Colorado, indicate significant price gaps between agriculture-to-urban and agricultural-to-agriculture transactions. For the Truckee Basin, the median price of 1,025 agriculture-to-urban water sales between 2002 and 2009 (2008 prices) was $17,685/acre foot (an acre foot = 325,851 gallons, about enough to meet the needs of 4 people for a year), whereas for 13 agriculture-to-agriculture sales over the same period the median price was $1,500/AF. For the South Platte, the median price for 138 agriculture-to-urban

[3] For additional discussion of western water markets, see Libecap (2011).

sales between 2002 and 2008 was $6,519/AF as compared to $5,309/AF for 110 agriculture-to-agriculture transactions.

Aggregating transactions across markets and time can compensate for limited comparable transactions within local markets in order to gain a sense of differences in value across sectors, recognizing the qualifiers noted above. The data reported here are from a data base of 4,220 observations from 1987 through 2008 as compiled by the author.[4] The dataset is not conclusive because transactions are likely to be missed, especially those that take place within organizations, such as irrigation districts.

Of the 4,220 transactions in the dataset with information on the transacting parties, amounts, and nature of use, a smaller number, 2,765, have price data. Table 1 shows mean and median prices per acre foot (an acre foot is 326,000 gallons of water) for leases and sales for agriculture-to-agriculture and agriculture-to-urban trades.[5] The prices for sales are given as the value per acre-foot of committed flow of water, which is analogous to a one-year lease price.[6] By discounting quantity flows, using the same methodology as for determining the present value of

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[4] The dataset currently includes 4407 transactions through 2009. Because 2009 transactions will continue to be indicated throughout 2010, the 2009 transactions currently in the database were excluded from the analysis. The full dataset and the methodology are described at http://www.bren.ucsb.edu/news/water_transfers.htm. See also Brewer, et al. (2008) for discussion of methodology.

[5] We converted all prices into dollars per acre-foot of water for comparison across time. Prices for one-year transactions were easily presented in per acre-foot terms. For example, if 1,000 acre-feet of water was leased for one year for a total price of $100,000, then the per-acre-foot price was $100.

[6] Consider a sale of 1,000 acre-feet of water for a total price of $2 million. The per-acre foot price is $2,000. This is the traditional method of showing sale prices. However, it is not directly comparable to the one-year lease price because the sale commits a flow of water to the buyer in perpetuity. In the example of a sale of 1,000 acre-feet of water for a total price of $2 million, using 5 percent to discount the quantity flows, leads to discounted sales price of $100 per acre-foot.

a perpetual bond, we calculate a single committed quantity. With this discounted quantity we convert the total sales price into a per acre-foot price that is directly comparable to a per-acre-foot, one-year lease price. Multi-year lease prices are treated similarly, using the same method as finding the present value of a multi-year bond and are combined with 1-year leases in Table 1. Based on historical use patterns, as much as 90% of western water is consumed in agriculture, but most new demand is for urban and environmental uses. [7] Accordingly, the trades reported are for movements of water within and out of agriculture.

<<Insert Table 1 here>>

As shown, the annual mean and median sale and lease prices for agriculture-to-urban transactions are significantly higher than are agriculture-to-agriculture trades (See statistical discussion below). This condition in part indicates the benefits of out-of-sector water transfers. Other factors, such as more senior rights that may be associated with agriculture-to-urban transfers and higher wheeling or conveyance costs, also explain the higher prices. Further, because sales involve the transfer of water rights and a perpetual claim on water flows as compared to leases, which involve a shorter-term (often one-year) transfer of the right to use water, sale prices will be higher than lease prices.

Figure 1 shows the patterns for agriculture-to-agriculture and agriculture-to-urban median prices over time for sales and one-year leases. A Wilcoxon signed-rank test[8] was performed and the yearly median price of agriculture-to-urban transfers is greater than that of agriculture-to-

[7] http://www.ers.usda.gov/Briefing/wateruse/

[8] The Wilcoxon signed-rank test is similar to the standard difference-in-means t-test. However, its non-parametric nature allows additional flexibility as it does not require a-priori assumptions on the distribution of its components. The statistical significance holds for the difference in means as well.

agriculture transfers at a 1 percent significance level.[9] In the dataset, agriculture-to-urban sales are dominated by transactions in Colorado on the Big-Thompson Project.[10] Although there are limited data on agriculture-to-agriculture sales outside Colorado, the median agriculture-to-urban sale price in the 11 western states excluding Colorado is much greater, $708/AF, than the median price of agriculture-to-agriculture sales, $251/AF.

<<Insert Figure 1 here>>

There are two primary reasons why there are fewer observations for agriculture-to-agriculture sales outside Colorado.[11] One is that agriculture-to-agriculture sales can take place within irrigation districts, and these transactions are likely to be missed in the dataset used here. The entire 22-year dataset only reports 613 agriculture-to-agriculture trades for the 12 western states. Brozovic et. al. (2002) report that in the Westlands Water District alone, where active intra-district trading takes place, 1,267 transactions occurred from 1993-1996.[12] The second reason is that irrigators in western states often rely on leases instead of sales. I examine this issue in more detail below, but basically leases are common because they involve low transaction costs with trades among neighboring irrigators. They typically do not require regulatory review. A Wilcoxon signed-rank test was performed on 1-year lease prices for the 12 western states, of which Colorado represents a very small portion of transactions. The test shows that the yearly median price of

[9] W=-183, p-value=0.0015.

[10] The Colorado Big Thompson institutional details are discussed later in the text.

[11] Of the 2765 priced transactions used in this analysis, 215 were Agriculture-to-Agriculture sales, 32 of which were outside of Colorado. In contrast, there were 1140 Agriculture-to-Urban sales with price data, with 211 taking place outside Colorado.

[12] http://www.ucowr.siu.edu/updates/pdfn/V121_A2.pdf

Agriculture-to-urban transfers is greater than that of agriculture-to-agriculture transfers at a 1 percent significance level.[13]

Welfare Gains from Greater Market Trading

The differences in the prices of traded water in the two categories indicates that at the margin there can be significant efficiency gains from re-allocating some water from agriculture to urban and environmental uses. Here we attempt to model what some of these gains might look like. There are several obstacles to modeling the efficiency advantages of water trades, but they fall into three broad categories. One, the physical aspects of water trades. Water price depends not only on supply and demand generally, but also on local conditions such as conveyance ability and water quality. [14] Two, the transaction costs associated with differing regulations and incomplete property rights regimes across jurisdictions. Regulations vary by state and within states there can be county restrictions on transfers. Three, because water markets are local due to conveyance costs and regulatory restrictions, they are thin so that there are limited observations for transfers and prices, and these data can be affected by observations that are not indicative of general patterns.

To see this, Figure 1 shows agriculture-to-agriculture sales prices approximating agriculture-to-urban prices from 2006-2008. The high-priced agriculture-to-agriculture sales in

[13] W=-158, p-value=0.003.

[14] Conveyance costs can be high. Water is heavy. An acre foot of water weighs 2,719,226 pounds (325,851 gal/AF x 8.435 pounds/gal) or 1,360 tons. Conveyance costs can be high. Hansen, Howitt and Williams (2007, 3) report that 55 percent of the $250 that the Metropolitan Water District of Southern California paid in 2002 for water from Northern California was for the cost of conveying it.

these years, however, took place within the Colorado Big-Thompson project, where administrative rules allow agriculture-to-agriculture and agriculture-to-urban transfers to occur freely, forcing agricultural users to pay the full opportunity cost of the water, which is the cost urban users are willing to pay. For example, the January 2007 issue of *Water Strategist* reported a number of trades from the Colorado Big-Thompson project, among them a transfer from an irrigator to a developer for $9,673 and from an irrigator to another irrigator for $9,626.

Given the observed differences in water values between agriculture and urban applications, it is interesting to estimate what the welfare gain might be under varying scenarios of a hypothetical increase in water trading from the agriculture to urban sector. We consider two cases: 1). if just a small amount (1%) of current irrigation water or 10 % of the current urban market, which ever were smaller, or 2). if 3% of irrigation water or 100 % of the current urban market, which ever were smaller, were transferred to urban use. These constraints are designed to minimize any impact on agricultural or urban sector water prices and to reflect what might be feasible for an urban market to absorb.[15] Kenny, et al (2009) provide estimates of the total and irrigated use of water in the U.S. by state and the Bren dataset http://www.bren.ucsb.edu/news/water_transfers.htm allows for trading estimates.

The state data are reported in Table 2, which provides estimates of total surface water used and in irrigation as of 2005, as well as the average committed volume of water transferred per year through all trades--sales, multi-year leases, and one-year leases, and that figure as a

[15] We assume that the additional transfers take place at the prevailing agriculture to urban market price. The net gain is this value, less the opportunity cost of water in agriculture as approximated by the agriculture-to-agriculture price.

share of total use and irrigation use.[16] The final column lists the median price difference between agriculture-to-urban and agriculture-to-agriculture transfers.

<<Insert Table 2 here>>

Table 3 outlines the hypothetical transfers. Note that the volume of water in the proposed additional transfers is small compared to the water used for irrigation or to total current transfers. Column two shows the value of current water transfers; column three the proposed increase under option (1); the associated welfare gain and its share of current transfers are in columns four and five; the increase under (2) in column six and the associated gains in columns seven and eight.

The net welfare gain from moving a very small amount of water to urban users under (1) is estimated at $12 million per year and under (2) at $98 million per year. These figures represent gains of 3% and 24% of the value of the yearly water market activity of almost $406 million. Even under the conservative conditions imposed in this exercise, there are significant annual welfare gains from increased movement of water from agriculture to urban uses. Any increases in trading are constrained by the existing (already small) size of the urban market. The estimates are illustrative only and some of the very large gains, such as in Colorado, Montana, Nevada, and Washington may be partially due to limited observations for agriculture-to-agriculture trades in the dataset. Nevertheless, they indicate the potential benefits of a more active water market. We now turn to a discussion of the nature of the current water market.

<<Insert Table 3 here>>

<u>Water Transfers in 12 Western States 1987-2008</u>

[16] As with discussed for Table 1, we convert all contracted amounts of water to a similar committed flow.

All western states allow for transfers of water. There are three types of transfers—permanent sales of water rights, short-term leases (1 year), and longer-term leases (up to 35 years or more). Among these, there are transfers among those who use the water for the same purpose—irrigated agriculture for example, or among those with different purposes—agriculture-to-urban or environmental, and transfers within a water basin (where sources are interrelated geologically) or across basins—out of one water region to another. Short-term leases within a basin among those who use water for the same purpose, such as farmers, typically have been the most common. Longer-term leases and sales of water rights often involve changes in the location and nature of use of water.

Figure 2 illustrates the yearly path of all transfers in the 12 western states from 1987 through 2008 as well as those for agriculture-to-agriculture, agriculture-to-urban, and agriculture-to-environmental trades. The figure shows that: (1) the total number of water transfers is increasing (statistically significant); (2) agriculture-to-urban and agriculture-to-environmental trades are also rising (statistically significant); and (3) agriculture-to-agriculture trades show no discernable trend (statistically insignificant).[17]

<<Insert Figure 2 here>>

Table 3 shows the nature of trades across states and by contract form from 1987 through 2008. Colorado dominates in terms of total market transactions, reflecting the institutional advantages of the Colorado-Big Thompson Project, which are described below and where most of the transactions are sales. Other active market states are California, Texas, Arizona, and

[17] Given that Colorado dominates the number of transactions, we note that the trends remain the same in terms of direction and statistical significance when Colorado transactions are removed.

Nevada. Within California and Texas short-term leases are the most prevalent contract, but multi-year leases and sales are also important. California's water institutional and regulatory environments explain the focus on short-term leases. In Arizona and Nevada, rapidly urbanizing, dry states, sales are common, but, not surprisingly, Montana and Wyoming, the least urban of the 12 western states, have the fewest water sales.

<<Insert Table 3 here>>

Table 4 breaks down the trading activity by state into the share that is within the agriculture or urban sectors and that which is from agriculture to urban. The differences between the annual flow and committed measures reflect the importance of sales and long-term leases in the latter. Again, there are important differences across the states. Among the leading water trading states, Arizona and California have relatively balanced transactions in recorded transactions, but Colorado, Texas, Nevada, and Washington show considerable activity to and within the urban sector.

<<Insert Table 4 here>>

As indicated above there is water market activity across the western states, and there are opportunities for more activity to address growing problems of scarcity and reallocation. The question is what measurement and equity issues will be encountered? To address these issues, we first turn to water rights.

Institutions: Western Water Rights

Appropriative Surface Water Rights

In western states, individuals do not own water as they might own land. This in itself is suggestive of the special nature of water. The state owns the water, which it holds in trust for its citizens. Individuals hold *usufruct* rights to the water, subject to the requirement that the use be beneficial and reasonable and to oversight by the state in monitoring use and water transfers to insure that they are consistent with the public interest (Gould, 1995, 94; Simms 1995, 321). Accordingly, there is a broad regulatory framework for water so that western water rights potentially have *less* protection and are more fragile than most other property rights (Sax 1990, 260; Gray 1994b, 262).

In most western states--Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming--all surface water rights are based on the prior appropriation doctrine that allows rights holders to withdraw a certain amount of water from a natural water course for beneficial purposes on land remote from the point of diversion (Getches, 1997, 74-189). The appropriative doctrine emerged in the 19th century in response to the development of mining and agriculture in the semi-arid West where growing numbers of people and economic activities were increasingly concentrated in areas where there was too little water (Kanazawa, 1998). Prior appropriation allowed water to be separated from riparian land and moved via canals and ditches to new locations (Johnson et al. 1981).

Appropriative rights are assigned through the rule of first possession or priority of claim. They grant rights to redirect a defined quantity of water from the source, based on the time of the initial diversion. Those with the earliest water claims have the highest priority and those with subsequent claims have lower-priority or junior claims. As such, there is a ladder of rights on a stream, ranging from highest in priority to the lowest. This allocative mechanism ranks competing claimants based on priority in order to ration water during times of drought.

Appropriative rights are to a *fixed* quantity of water to be diverted from the water source (surface or ground water), but transfers of water that change the point of diversion, timing, or nature of use generally are based on the amount of water *consumed* (MacDonnell, 1990, Vol. I, p. 11).[18]

Under prior appropriation there is a critical interdependence among diverters from the same water source with different priority rights. Because as much as 50 percent of the original diversion may flow back to the stream or percolate down to the aquifer, it is available for subsequent users (Young, 1986, 1144). During times of drought when only senior appropriators may have their allotments fulfilled, junior appropriators are especially dependent upon these return flows. They bear most of the downside risk of drought. Actions by senior rights holders that affect water consumption and can influence the amount of water released downstream. Accordingly, water trading from agriculture to urban uses that involves export out of the basin can impair third parties and is subject to state regulation to insure that no harm is inflicted on junior diverters (Getches, 1997, 161). This is an issue to which we will return.

Riparian Surface Water Rights

In the eastern states, water rights are based on ownership of land appurtenant to water flows. Riparian land owners have rights to access the water adjacent to or passing through their properties for reasonable use, including fishing and navigation, and can utilize the water so long as doing so does not harm other riparian claimants downstream (Getches 1997, 33). In cases of drought, all parties share in the reduced water flow. Riparian water rights are tied to the land can only be transferred with adjacent properties.

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[18] 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. Howitt and Hansen (2005, 60) point to both transaction costs through property rights and regulatory differences and often high costs of transporting water. See also Smith (2008) for discussion of water rights in a semi-commons setting.

Of the 12 western states examined here, the wettest states, California, Texas, Oregon, and Washington have a hybrid of prior appropriation and riparian systems, whereas the drier 8 states have prior appropriation only (Getches 1997, 8). When the two systems operate, there can be questions of priority of claim when diversion under the appropriative system seriously reduces the water available to riparian owners. Alternatively, riparian claims could prohibit diversion from streams as part of appropriative water claims. In western states, riparian claims have been limited, although in California they are given precedence in disputes with appropriative claimants under certain circumstances (Getches 1997, 87-93, 192-97).

Groundwater Rights

Groundwater rights vary across the western states and most are not as well defined as are surface water rights (Thompson 1993, 684). Most groundwater rights allow surface land owners access to a reasonable use of groundwater (Getches 1997, 251). With multiple, fragmented surface properties and the vague standard of reasonable use groundwater basins can be subject to competitive withdrawal and classic common-pool conditions.[19]

These are the basic water rights in the western U.S. Their definition and enforcement are affected by the physical characteristics of water, regulatory standards, and the many parties that have a say in the exchange of any water right.

Efficiency and Equity: The Physical Characteristics of Water: Property Rights, Equity and Public Interest Demands.

Because of its fluid nature and that fact that many parties use water sequentially or simultaneously, there are significant resource and political costs in defining private water rights.

[19] Provencher and Burt (1993), Glennon (2002, 209-24). For similarities with oil pools, see Libecap (1989, 93-114).

To see the effects of its physical characteristics, it is useful to compare water with land, which is fixed and observable, and with mobile, wild-ocean fish stocks, which are mobile like water, with regard to characteristics that affect the costs of defining and enforcing property rights.[20] Table 5 lists the three resources and the characteristics--ability to bound, partition, and exclude; measure size and amount; variability of supply; existence of simultaneous and sequential uses. The signs reported in each cell indicate how the characteristic impacts the costs of definition of property rights for the resource, with a plus sign indicating that it contributes to definition and a negative sign indicating that it hinders definition. As can be seen, water is more similar to migratory fish stocks than to land in terms of the costs of bounding, exclusion, and measurement.

<<Insert Table 5 here>>

The Costs of Bounding

Because it is a liquid, surface and groundwater cannot be bounded or partitioned easily across claimants and uses (Smith, 2008). This characteristic is also generally true for fisheries, where numerous competing fishers can exploit the same mobile stock as an open-access resource.[21] Ownership to both resources is granted only upon extraction (diversion for water, harvest for fish) under the rule of capture. Stationary land is fixed and observable so that bounding costs are much lower. It is possible to fence and partition land to meet concurrent and sequential demands for farming, urban development, pastoral scenery or other amenities, such as provision of wildlife habitat.

[20] For discussion of property rights in land, see Ellickson (1993, 1327 for discussion of ease of monitoring boundaries; 1362-3 for discussion of the bundle of property rights in land; 1381 for discussion of partitioning land across private and public uses.

[21] See Hannesson (2004).

The Costs of Measurement

Fluidity and in the case of groundwater, a lack of observability, also raise the costs of measuring a water right. For this reason, ownership is based on the amount diverted or pumped (Johnson, et al, 1981, 279). The amount actually diverted, however, varies over time due to fluctuating precipitation that affects stream flow, reservoir size, and groundwater recharge. Seasonal precipitation patterns generally are predictable and can be incorporated into a water claim, but long-term variation due to drought is less predictable, adding uncertainty to water supply and diversion amounts associated with a water right.

Mobile, unobserved fish stocks have comparable measurement problems. The stock is affected by natural growth (recruitment), disease, ocean temperature, food supplies, pollution, and harvest in ways that are often poorly understood. As a result, rights to fish or catch shares such as individual transferable quotas (ITQs), are based on the percent of the annual allowable catch, not to a fixed amount of fish.[22] In contrast, there is no comparable problem for measuring fixed, observable land plots, where rights can be well defined with more certainty.

The Interconnected Private and Public Goods Characteristics of Water

Because water diverters sequentially access the same (unconsumed) water and because there are associated amenity, riparian, and aquatic habitat values often simultaneously supplied, private and public water uses are intertwined to an extent not found for land or fish stocks (Smith, 2008; Hanemann, 2006). The interconnected nature of water uses and values is a basis for state regulation of water rights and water trades. Although public goods or public interest claims have merit, these equity concepts can be so broad and elastic that they can be asserted in

[22] The New Zealand quota system began by assigning fixed amounts of fish, but was changed to a percentage of allowable catch. See Connor and Shallard (2010, 349).

the political and judicial processes by special interests to weaken property rights and the efficiency benefits they can provide for incentives for wise use, conservation, and exchange.

Equity and Politics: Regulatory Constraints and Water Rights

Beneficial Use, Diversion Requirements, Preferential Uses

Appropriative water rights are conditional upon placing the water into beneficial use--the use-it-or-lose-it mandate and no injury to third parties. Beneficial use was included in the appropriative doctrine as a low-cost way of determining if there was excess water to be assigned. Most western states define beneficial use generally as a use for the benefit of the appropriator, other persons, or the public with corresponding lists of what is considered beneficial use. Preferred applications vary somewhat across the states. Although, irrigation was the dominant initial basis for diversion, the set of beneficial uses can be expanded or contracted based on changing public values, judicial interpretations, and constituent group politics. For example, leaving water in-stream for habit recently has been accepted as a beneficial use across the states although its exact definition differs among them (Getches, 1997, 113-4).[23]

The vague concept of beneficial use provides the basis for a potentially broad regulatory mandate (Getches, 1997, 128-9). Because of this, the determination of beneficial use and diversion requirements consistent with it make water rights vulnerable to shifting legal and political interpretations, adding uncertainty to the water right. Historically, physical diversion and complete use of diverted water was deemed consistent with the doctrine and maintenance of a water right. But it has motivated irrigators to place water into low-valued applications, even though its use elsewhere might have higher values. Further, until recent changes in state law recognized conserved water as consistent with beneficial use, irrigators avoided conservation.

[23] See Anderson and Johnson (1986) and Scarborough (2010) on in-stream flows.

Any conserved water could be interpreted as evidence of a lack of beneficial use of the past allotment and therefore be subject to claiming by other diverters (Getches, 1997, 128).

The "No Injury" Rule (Third Party Effects), Area of Origin Restrictions

Third party impairments are technical impacts resulting from the consecutive use of water. As noted above, changes in the timing, location, and nature of use can affect the amount and quality of water consumed or released to the stream for subsequent users or uses. In this event, junior rights holders especially could be harmed, and this is known as third-party impairment or a third-party effect. The prospect of third-party impairment has led western states to implement judicial or administrative procedures that must be followed before water use can be altered or water rights transferred. Although these procedures vary from state to state, they typically allow water use changes or water rights transfers only if there is no damage to other water rights holders, the "no injury rule" (Thompson 1993, 701;). Water transfers that are unlikely to have these impacts, such as trades among adjacent irrigators, typically do not require state approval because any third-party impairment is minimal.

As a result, most trades that could impact release flows must be approved by state regulatory agencies. Petitions for trade must specify the amount of water involved, the duration of the contract, the timing of the exchange, the type of water right, consumptive use, and possibly hydraulic and other legal information. The agency evaluates the proposal to determine whether third-party effects are involved. Notice of the proposed change is published so that objections to the change may be filed. The burden of proof of no harm from the transfer usually rests with the applicant. The outcome of administrative review includes approval, approval subject to modification, or denial, as well as provision of opportunities for appeal (Colby, 1995, 114).[24]

Any objections by junior appropriators downstream or others may be resolved by adjustments in the amount of water, timing, or allowable uses in the exchange. Monetary payments or other forms of compensation also may be included. The resolution of other third party complaints, however, may not be so straightforward. If substantial amounts of farm land are fallowed, there could be reduction in local demand for farm labor and in wholesale and retail trade within rural communities. Assessing the legitimacy, basis, and appropriate size of compensation to be paid for possible pecuniary impacts on farm labor and local merchants is complicated. There must be agreement on the damages, who should pay, and the terms and conditions of payment. All of these are likely to be controversial, and they potentially weaken water rights and reduce the gains from water reallocation.[25]

Additional third-party claims are apt to be even more difficult to assess. Rural politicians may find their political base eroded if large water transfers led to a decline in agricultural activities. Other local officials, including school district administrators and county extension agents may be similarly affected. Because these damages are hard to measure, monetary payments would be difficult to determine, and more importantly, under current law and political practices would be illegal. Accordingly, local politicians and bureaucratic officials may have an incentive to oppose water trades in their own self interest as well as in the interest of other constituencies who may be harmed.

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[24] See also Colby, Bonnie G., Mark A. McGinnis, Ken Rait (1989) and Colby (1990).

[25] For examination of bargaining over pecuniary benefits of water transfers, see Libecap (2008).

Despite these concerns, most studies suggest that third-party pecuniary effects will be small. Only limited amounts of water and fallowing are involved in most transactions. Water placed in low-valued uses is traded first, and as the amount of water involved increases, its marginal value rises. As water prices increase, alternative urban and environmental users demand less. And there are monetary and efficiency benefits from the sale and more efficient use of water (Hanak, 2003 p. x-xii, 72; Howitt, 1994). Hanak (2003, 81) points out that effects of fallowing irrigated farmland are likely to have no more than a one percent effect on overall county economic activity, even when payments for economic adjustments are not included.

Third-party impairment can be a legitimate concern given the sequential uses of the same water by junior appropriative rights holders. At the same time, how it affects water rights and water transfers depends upon how the problem is interpreted legally and the range for objections. If third-party impairment is strictly defined and limited to downstream, junior rights holders, who would feel a direct impact, then regulatory review is consistent with efficiency. If the problem is broadly defined to include multiple other constituencies and claims of harm, then inefficient rent-seeking becomes more probable, particularly given the high prices offered for water in some cases.

The regulatory process varies across the western states—in part reflecting the differential complexity of water supply and use and in part reflecting different supply and demand conditions. Two examples are provided to illustrate the process of regulation within the states.

California generally has pro-transfer legislation, but the regulatory and property rights environments are less supportive. These include mixed jurisdictions among state and federal agencies, a patchwork of county regulations of groundwater withdrawal and export, and a complex system of water rights with differential requirements for agency review (Gray 1994a, 178). For example, only transfers of surface water rights acquired since 1914 require approval of the State Water Resources Control Board (SWRCB). Exchanges within the huge Central Valley Project (CVP), where the Federal Bureau of Reclamation has jurisdiction, usually involving short-term agricultural water trades, do not involve the SWRCB (MacDonnell (1990, Vol. I, 17-8, 24, Vol. II, Gray, 3-13). Because there so many irrigation districts and supply organizations within the CVP with interlaced claims to water, any transfer by one entity to outside buyers is apt to affect another claimant, triggering a regulatory review. The SWRCB also can deny a proposed water transfer if would "unreasonably affect the overall economy of the area from which the water is being transferred."[26] As a result, the administrative process of transferring water in California can be lengthy and complex, and the outcome uncertain.

Further, California counties are able to restrict extraction and export of groundwater out of county through area-of-origin restrictions. As of 2002, 22 of 58 counties had done so (Hanak, 2003, vii; Gray, 1994a, 180; Hanak and Dyckman, 2003). These county ordinances similarly can limit surface water transactions if they appear to diminish groundwater resources, either through lowered recharge or through greater farmer reliance upon pumping. Although there are legitimate groundwater issues at stake, recent research by Hanak (2003, viii) suggests that the overriding aim of the ordinances is to keep water within rural counties and limit reallocation to urban or environmental uses.

In Colorado there are different regulatory structures for the Northern Colorado Conservancy District that manages Colorado Big Thompson (CBT) water and for other parts of the state. In most of Colorado, water courts handle impairment claims for proposed water transactions. In the CBT, the courts do not have jurisdiction. Unlike more common appropriative

[26] CA Water Code § 386

water rights, within the CBT each water right holder has the same priority and legal claim to a number of *uniform* water units that are tradable. The amount of water in each unit fluctuates annually based on water supply. All shareholders are adjusted in the same manner. Return flows from any diversion are captured by the district so that all diversion effects are internalized district wide. Because shares are homogenous, transfers across users, especially across sectors, occur with minimal fees and paperwork (Thompson, 1993, 719; Carey and Sunding, 2001, 305). In effect the Colorado Big Thompson has a cap-and-trade framework and has by far the most active water market in the West in terms of numbers of trades. Sales prices for all uses are comparable as they should be when opportunity costs are incorporated, water quality and right priority are the same, and transaction costs are low.[27]

Public Resource, Public interest, Public Trust

For many, water is so critical and uses of it so complex, that there are calls for it to be a public resource (Bates, Wilkinson, MacDonnell, and Getches, 1993, 185): "A hard look at water policy should seek distributional fairness. . . . The public, through some acceptable process, must first decide which waters are for public use and which are available for private use within a market system. . . . [Private] appropriation ought to be limited to the amount that is not needed by the whole community for the satisfaction of public values." Similarly, Dellapenna (2005, 35) argues that the best option is to "treat water as inherently public property for which basic allocation decisions must be made by public agencies."

[27] For example, sample agriculture-to-urban and agriculture-to-agriculture sales were priced at $9,350 and $9,300/unit respectively, as reported in the October 2008 *Water Strategist*, p. 7. The CBT also has the advantage of using water stored in a reservoirs, imported from elsewhere, providing a less complex case than when flowing streams are the water sources (Hansen and Howitt, 2005, 60).

To the extent that these equity demands are based on the public goods nature of water, then they have to be weighed in the assignment and trade of private water rights. Indeed, most western states require administrative agencies to consider the public interest in reviewing applications for new water rights (Bretson and Hill, 2009, 745). To the extent, instead, they are used primarily by certain parties to constrain existing property rights and water trades in their behalf, there can be important efficiency implications. The broader the interpretation of the public interest in water, the weaker the private interest in it and the ability of property rights to avoid open-access conditions, to channel the resource to higher valued uses through market exchange, and to encourage conservation and investment.[28]

As the public interest is expanded to include a more expansive array of uses and constituencies, many of which may be only loosely defined, more parties may assert a basis for disputing ownership and potential trades. As regulatory-based transaction costs rise, water will flow less easily to higher valued uses, underscoring the persistent differences in water prices indicated in Table 1 and Figure 1 above.

It can be claimed legitimately that certain public goods values will not be reflected in market prices. Those claims require careful consideration and there are techniques, such as contingent valuation, for assessing non-market values. Under those circumstances, water could be purchased by state agencies or non-government organizations for public good applications. This practice occurs, for example, in purchases or leases of water for in-stream flows by organizations such as the Oregon Water Trust (Neuman, 2004, Scarborough, 2010). The value of

[28] Public access conflicts are examples of the efficiency/equity trade-offs that exist in the West. In one case, at least, the water resource appears to have suffered from judicial rulings upholding the right to access. See http://missoulanews.bigskypress.com/missoula/the-battle-for-mitchell-slough/Content?oid=1135390.

such transactions is that the opportunity cost of water becomes clearer. This information affects both the behavior of current water rights holders as sellers (often irrigators) and in-stream purchasers, so that more water is smoothly transferred without costly controversy to higher-valued uses.

A broader public interest mandate also means that more allocative and management decisions necessarily will be directed to the state and the political process. The record of state regulation of open-access fisheries, for example, is not one of success, and privatization of fisheries has resulted in significant rebounds of the stock (Costello, et al 2008). Whether or not this same result would apply for water remains to be seen, but the call for a wide interpretation of the public interest and hence, greater state ownership and management should consider the conditions under which this institutional arrangement would be effective.

As part of this evaluation, more attention should be directed toward constituent group politics and the determinants of political and bureaucratic decision making in the process of effective water management (Peltzman, 1976; Becker, 1983). In light of possible climate change and growing scarcity of water, the social losses of inefficient water management and allocation could be high.

A concept related to the public interest is the public trust doctrine, which is a common law principle creating the legal right of the public to utilize certain lands and waters, such as tidewaters or navigable rivers, and other waters and natural resources with high amenity or public goods values (Getches, 1997, 217, 224-8). Under the doctrine, the rights of the public are vested in the state as owner of the resource and trustee of its proper use. In a far-reaching ruling by the California Supreme Court in 1983 in the Mono Lake case (*National Audubon Society v. Superior Court* 685 P.2d 709, 712) the court stated that the "core of the public trust doctrine is the state's authority as sovereign to exercise a continuous supervision and control over" the waters of the state." The doctrine can be applied retrospectively to roll back pre-existing appropriative rights that appear inconsistent with the public trust. There apparently is no constitutional basis for taking challenges of public trust restrictions of private water rights (Simms, 1995, 321; Sax 1990, 264, 269).[29]

Because water is a mixed resource providing private and public goods, there can be justifiable concerns about private water use that potentially harm public values. The benefits of public trust interventions, however, have to be weighed carefully against the value of the private uses to be restricted or prohibited. The doctrine is so elastic and potentially expansive that it can lead to extensive government intrusion in water rights. The doctrine, then, potentially adds uncertainty to water ownership, weakening existing property rights and their ability to promote investment, trade, and efficient use of water.

Equity, Politics, and Bureaucratic Incentives: The Parties Involved in Water Transactions

Although water rights holders and prospective purchasers or lessees are key parties in any exchange, other institutions play key decision-making roles in the timing and extent of water trades. Their actions affect the transaction costs of exchange and the development of water markets. The institutional complexity surrounding water rights and marketing far exceeds anything comparable for land and even perhaps for fisheries with their myriad mixes of fishers, processors, state, federal, and international management organizations.

<u>State Regulatory Agencies, Water Supply Organizations, Indian Tribes</u>

We have already discussed the role of state regulatory agencies that must approve water transactions. Additionally, there are approximately 1,127 water supply organizations across 17

[29] See also, Blumm and Schwartz (1995).

western states.[30] These institutions vary widely in terms of governance structure, membership, decision-making authority, and water rights. Many hold water rights in trust for their members, whereas in some others the rights are held by the users. The organizations range from irrigation districts, mutual ditch and reservoir companies, water conservancy districts, municipal water districts to water companies. This organizational complexity increases the number of decision rules and the transaction costs of defining clear property rights and of transferring water (Bretson and Hill, 2009).

For example, the governing boards of irrigation districts, the most common type of water supply institution, can be elected by members or by community voters. The voting rule can affect how the board responds to water transfer requests. Districts where members elect the governing board appear to respond more quickly to changes in water values and water market opportunities than do districts where the governing board is elected community wide, where the interests are very heterogeneous and equity issues loom large.

The differential experiences of the Palo Verde (PVID) and Imperial Irrigation Districts (IID) in negotiations to sell or lease water are illustrative. The PVID Board is elected by members only whereas the IID Board is elected by community voters. In the case of publically-elected boards, members may be much less interested in selling or leasing water under their jurisdiction than are land owners (Thompson, 1993, 678, 728, 740; Eden, et. al, 2008; and Rosen and Sexton, 1993). The PVID board reached agreement to fallow land and transfer water for

[30] Water User's Organization Roster, US Department of Interior. Bureau of Reclamation, as well as state agency sites; Leshy (1982).

urban use with little controversy, whereas the IID board was mired in lengthy, complex negotiations.[31]

In addition to irrigation districts, the Federal Bureau of Reclamation is often involved in any water exchange. The Federal Bureau of Reclamation is the largest wholesaler of water in the U.S. and it provides irrigation water for 140,000 farms covering 10,000 acres in 17 western states. It has over 600 dams and reservoirs to capture and divert water, historically, mostly for irrigation.[32] The Bureau provides water to the irrigation districts through long-term service contracts. The Bureau can hold an appropriative right to the water within a reclamation project and the water is distributed anywhere within the project. The agency historically has had uneven policies toward water transfers (Thompson, 1993, 719-23). It also can arbitrarily adjust water deliveries to farmers in response to competing demands, such as under the Endangered Species Act, without legal impairment to their perceived water rights. This weakens the security of any water rights that farmers thought they held, reducing their incentives for wise use and transfer (Bretsen and Hill, 2009, 741-2).[33]

The water held by Indian tribes potentially is a major source of water for marketing. Indian tribes have reserved water rights sufficient for the development of agriculture on their reservations. Their water rights date from when the reservation was established by treaty with the federal government, which was usually in the 19th century, and therefore generally supersede the

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[31] Haddad (2000, 77, 95-116); Northwest Economic Associates (2004, 1-5); Hanak (2003, 72-3); Thompson (1993, 729, 757) and Glennon (2010, 258-71) discuss the Imperial Irrigation District's negotiations with San Diego and the MWD.

[32] www.pvid.org/; http://www.usbr.gov/main/about/

[33] As noted by Bretsen and Hill, 2009, 742, point out, in 1993 when the Bureau cut deliveries to the Westlands Water District by 50 % to meet environmental needs, the Ninth Circuit Court ruled that the agency had not breached its contract with the district.

priority of non-Indian claimants. Many of these treaty provisions have only been recently enforced and Indian water rights adjudicated through litigation or congressional statute. As water prices have risen, tribes have begun to be active participants in water markets.

Many parties, then, are involved in water transactions. Their differential interests raise the transaction costs of water trades and potentially weaken water rights.

Concluding Remarks: Water Rights, Water Markets, Efficiency and Equity Concerns.

This chapter has outlined the complex nature of water as a mixed private/public resource, and how that characteristic, as well as its physical qualities complicate its management and allocation. Although the focus here has been on the U.S. West, similar conditions exist in other semi-arid regions where increased fresh water scarcity is raising pressures for more efficient water use and management as well as greater equity demands.

Efficiency and equity demands often collide in a manner that inhibits action and sustains the status quo. This situation, however, is not sustainable as demands on a limited water resource grow. There is both a greater need to facilitate the smooth reallocation of water from historical to new uses and to improve management of this most critical resource, as well as to provide for more environmental, amenity, and recreational uses. Firmer water rights and greater reliance upon water markets can address efficiency concerns, and equity issues can be addressed in the allocation of water rights and in the regulatory process. But the latter cannot go too far if the efficiency advantages of secure rights and markets are to be available for this all-important resource. There are efficiency/equity trade-offs, and policies toward water must reflect this recognition.

Critics of appropriative water rights and water markets are explicit in outlining market failure. There is not, however, a similar level of precision in defining how the political/judicial/administrative processes will function to effectively manage and distribute water, let alone address equity concerns, to meet growing challenges regarding the resource. Yet, these issues must be addressed before greater authority over water is shifted to the state as part of a public interest mandate. Comparative institutional analysis is necessary to determine how much decision making over water will be left optimally to private rights and (regulated) markets and how much will be delegated to the political, judicial, and administrative processes. Water demands no less.

Table 1: Water Transfer Prices by Sector 1987-2008 (2008 dollars per committed acre foot)

	Agriculture-to-Urban Leases	Agriculture-to-Agriculture Leases	Agriculture-to-Urban Sales	Agriculture-to-Agriculture Sales
Median Price	$74	$19	$295	$144
Mean Price	$190	$56	$437	$246
Number of Observations	204	207	1,140	215

Source: Author's calculations from dataset http://www.bren.ucsb.edu/news/water_transfers.htm

Table 2: Surface Water Use (2005) and Average Water Trading Volume, Western US 1987-2008

	Surface Water Use (2005)		Current Total Water Transferred per Year (Committed)*			
State	Total (AF)**	Irrigation (AF)	Average Volume (AF)***	As % of Total Use	As % of Irrigation Use	Median Price Difference (Agriculture -to-Urban minus Agriculture -to-Agriculture)
AZ	3,154,970	2,540,000	1,056,749	33.5%	41.6%	$17
CA	22,087,390	15,700,000	1,939,336	8.8%	12.4%	$30
CO	10,984,830	10,000,000	779,478	7.1%	7.8%	$232
ID	15,169,140	12,700,000	491,005	3.2%	3.9%	N.A.
MT	9,736,660	9,530,000	28,698	0.3%	0.3%	$45
NV	1,374,870	828,000	118,677	8.6%	14.3%	$175
NM	1,611,860	1,550,000	221,979	13.8%	14.3%	$54
OR	5,077,910	3,780,000	442,625	8.7%	11.7%	$10
TX	6,695,160	1,680,000	1,735,658	25.9%	103.3%	$15
UT	4,117,390	3,610,000	228,932	5.6%	6.3%	$22
WA	3,765,180	2,890,000	183,402	4.9%	6.3%	$25
WY	3,663,120	3,570,000	48,835	1.3%	1.4%	$77
Total	**87,438,480**	**68,378,000**	**7,275,374**	**8.3%**	**10.6%**	

Sources and notes: *Using committed amounts as calculated by the author from the dataset http://www.bren.ucsb.edu/news/water_transfers.htm makes sense because it reflects the full amount of water obligated under the contract. Using the annual flow of the first year of the contract would understate the amount of water involved. See Brewer et al (2008).
** Kenny, et al (2009) provide estimates of the total and irrigated use of water in the U.S. by state and the Bren dataset allows for trading estimates by author. Excluding water used for thermoelectric cooling. This category includes surface water use for public consumption, agriculture (irrigation, livestock, and aquaculture), industry, and mining.
*** Average volume is the sum of all committed flows transferred in each year, averaged over the 22-year period recorded in the dataset. Because transactions often are for multiple years, the data here are calculated by the author to reflect longer time horizons. Although we might say 10,000 AF was transferred in 2008, we really mean the discounted sum of committed flows for the duration of the transaction is 10,000 AF in 2008—some of the flows are actually transferred in later years. This allows for a consistent treatment of prices.

Table 3: Potential Gains from Increased Ag-to-Urban Transactions*

State	Current Average Annual Market Value (All Transfer Types and Sectors) **	Proposed new Agriculture -to-Urban Transfers (AF)***	Net Welfare Gain from Additional Transactions****	Net Welfare Gain as % of Current Market Value	Proposed Agriculture -to-Urban Transfers (AF)*****	Net Welfare Gain	Net Welfare Gain as % of Current Market Value
AZ	$38,811,748	25,400	$440,362	1%	76,200	$1,321,087	3%
CA	$223,477,457	71,126	$2,135,504	1%	471,000	$14,141,453	6%
CO	$40,819,066	31,084	$7,224,465	18%	300,000	$69,725,433	171%
ID	$5,194,129	N.A.	N.A.	N.A.	40,710	$0	
MT	$294,998	1,186	$53,692	18%	11,858	$536,920	182%
NV	$4,191,448	2,185	$382,668	9%	21,854	$3,826,683	91%
NM	$36,334,302	14,570	$782,415	2%	46,500	$2,497,023	7%
OR	$10,014,045	151	$1,456	0%	1,509	$14,562	0%
TX	$39,093,722	16,800	$251,868	1%	50,400	$755,604	2%
UT	$6,328,674	17,820	$388,094	6%	108,300	$2,358,663	37%
WA	$1,097,697	9,016	$225,025	20%	86,700	$2,163,814	197%
WY	$267,649	772	$59,365	22%	7,721	$593,651	222%
Total	**$405,924,936**	**190,110**	**$11,944,915**	**3%**	**1,222,753**	**$97,934,893**	**24%**

*Sources and notes:** Author's calculations. Differences that occur are the result of rounding.

**This is the sum of the total price of every transaction from 1987-2008 in 2008 dollars divided by 22 years to arrive at a yearly average.

***1% of surface irrigation water in AZ and TX, and 10% of current agriculture to urban market for CA, CO, MT, NV, NM, OR, UT, WA, WY.

**** Net welfare gain is price difference (Ag-to-Urban minus Ag-to-Ag) multiplied by volume of additional transfers.

***** Transfer Minimum of 3% Irrigation Volume, or 100% Current Urban Market Volume, whichever was smaller. The large welfare gain as shown in Colorado likely reflects the difference in high prices paid for water within the Colorado-Big Thompson District discussed in the text.

Table 4: Share of each Transfer's Classification to a State's Total Quantity Transferred

	Annual Flow				Committed			
	Agriculture-to-Urban	Agriculture-to-Agriculture	Urban-to-Urban	Total (Million AF)	Agriculture-to-Urban	Agriculture-to-Agriculture	Urban-to-Urban	Total (Million AF)
AZ	15%	46%	39%	8.34	31%	37%	32%	21.72
CA	41%	32%	27%	5.04	37%	32%	31%	12.60
CO	51%	29%	20%	0.59	75%	8%	17%	5.88
ID	39%	55%	6%	1.59	29%	67%	5%	2.36
MT	55%	45%	0%	0.02	95%	5%	0%	0.22
NM	15%	78%	7%	0.10	36%	55%	10%	0.91
NV	84%	0%	16%	0.22	72%	0%	28%	2.39
OR	0%	100%	0%	0.10	0%	100%	0%	0.29
TX	48%	15%	37%	1.75	50%	3%	47%	25.30
UT	38%	32%	29%	0.31	53%	3%	44%	4.05
WA	49%	36%	15%	0.16	79%	3%	18%	1.93
WY	37%	63%	0%	0.10	38%	62%	0%	0.41

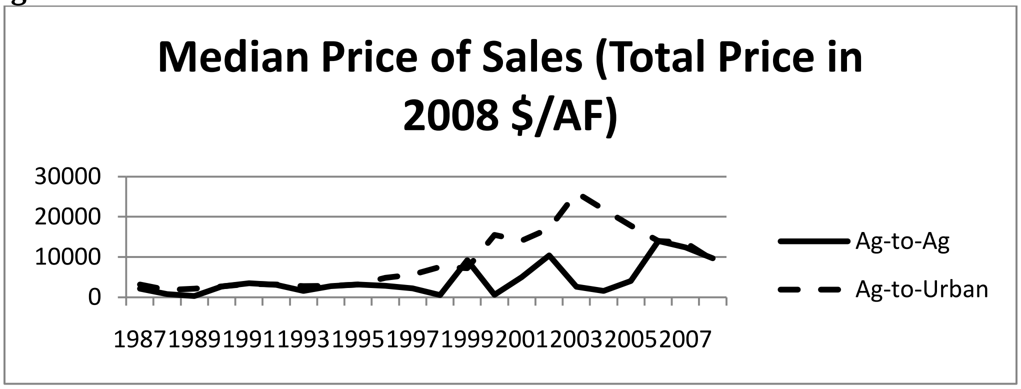
Source: Author's calculations from dataset http://www.bren.ucsb.edu/news/water_transfers.htm.

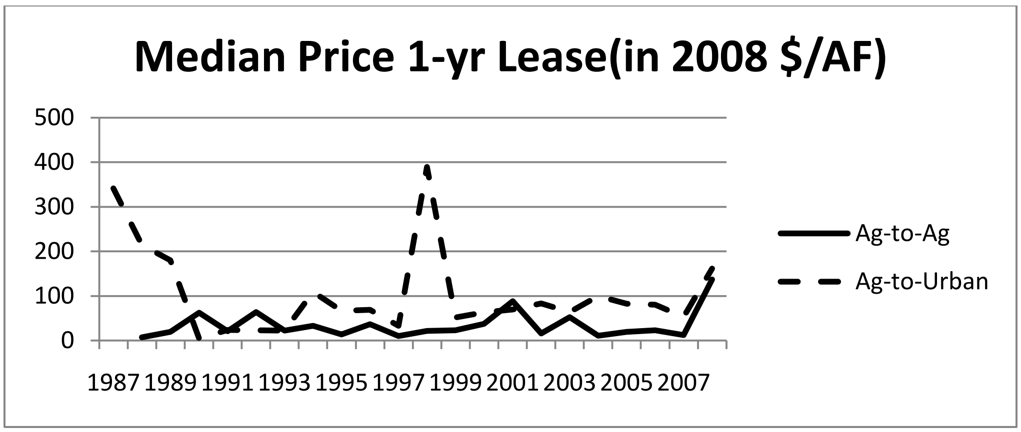
Table 5: Resource Characteristics

Resource	Ability to Bound, Partition, Exclude	Measure Size Amount	Variability of Supply	Simultaneous Uses	Sequential Uses
Land	+	+	+	+	+
Fish Stocks	-	-	-	-	-
Water	-	-	-	-	-

Source: Author's calculations.

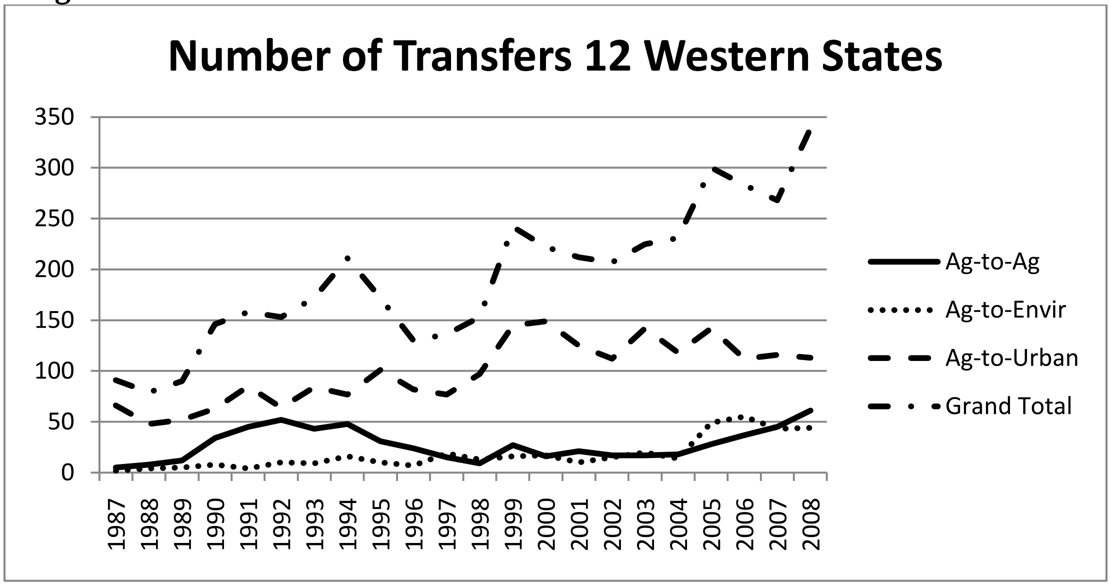
Figure 1: Prices Over Time





Source: Author's calculations from dataset http://www.bren.ucsb.edu/news/water_transfers.htm

Figure 2



Source: Author's calculations from dataset http://www.bren.ucsb.edu/news/water_transfers.htm.

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