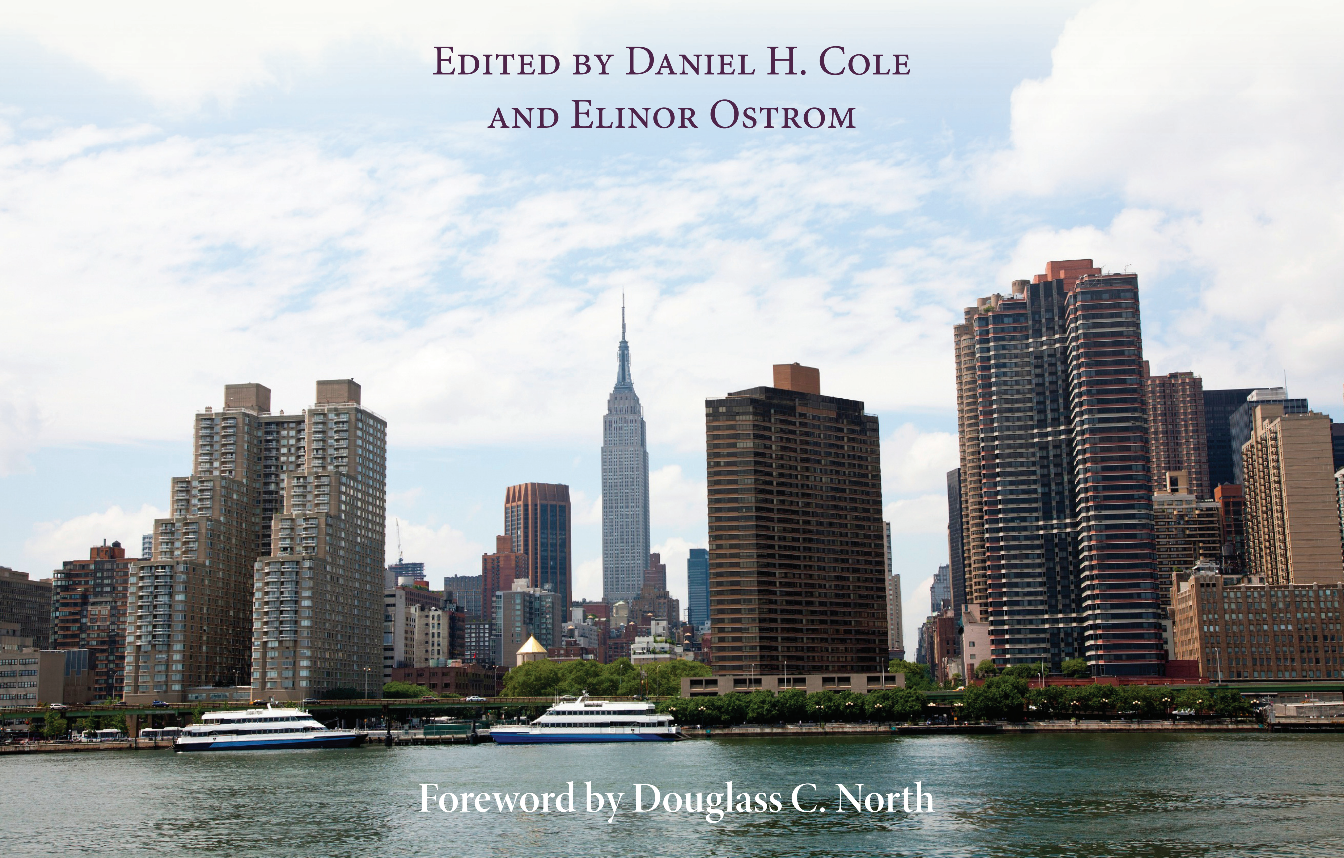
Property in Land and Other Resources

Edited by Daniel H. Cole
and Elinor Ostrom



Foreword by Douglass C. North

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GARY D. LIBECAP

There is growing concern about the availability of fresh water worldwide. As per capita income rises and populations grow, demands for water for human consumption, 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 Programme 2009). As water values rise because of increasing 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 address allocation, management, and conservation pressures more effectively.

In a classic article, Harold Demsetz (1967) described a process of property rights development and market activity as asset values rise exogenously. Indeed, institutional arrangements for many resources, such as hard-rock minerals and oil and gas reservoirs in the United States, developed in a manner consistent with Demsetz's hypothesis (Libecap 1978; 2007; Libecap and Smith 2002). In a broader context, commodity markets adjust rapidly to price differentials and reallocate the assets so that price gaps narrow over time. However, this process of property rights formation and price convergence is not happening as quickly for fresh water in the western United States (Brewer et al. 2008; Young 1986).

There are both high resource and political costs of defining and enforcing property rights to water and of managing it with markets. This chapter examines these issues in 12 states in the semiarid U.S. West, where many of the intensifying demand and supply problems regarding fresh water are playing out.[2] To understand the problems of expanding water markets, it is critical to address the varying political, bureaucratic, and administrative incentives involved.

There are major differences in water prices across uses (agriculture, urban, environmental) in the western states that cannot be completely explained by differences in conveyance costs and water quality. Therefore, it appears that water markets have not developed fully enough to narrow the gaps. Moreover, the extent and

[1] The *Economist* (April 8, 2009, 52) speculates that no more than 20 percent of the available water can be "safely" withdrawn by humans on an ongoing basis without a negative impact on the natural environment.

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

nature of water trading vary considerably across these states, most likely because of differences in water values and transaction costs of trade. This chapter's discussion of the resource and political costs of defining water rights and the use of markets shows that efficiency and equity issues often conflict. This tension reflects the social nature of the water resource.

Efficiency: The Extent of Water Trading

Water Price Differentials

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

Price differences across uses illustrate opportunities for exchange, but assembling data is difficult 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, available price data must be examined with caution, but the patterns indicate the thinness of many water markets and of the efficiency gains from further reallocation.[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, show significant price gaps between agriculture-to-urban and agriculture-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 per acre-foot (AF; an acre-foot is 325,851 gallons, about enough to meet the needs of four people for a year), whereas for 13 agriculture-to-agriculture sales during the same period the median price was $1,500/AF. For the South Platte, the median price for 138 agriculture-to-urban sales between 2002 and 2008 was $6,519/AF; for 110 agriculture-to-agriculture transactions, the median price was $5,309/AF.

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

Of the 4,220 transactions in the database with information on the transacting parties, amounts, and nature of use, a smaller number, 2,765, have price data. Table 13.1 shows mean and median prices per acre-foot for leases and sales for agriculture-

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

[4] The database currently includes 4,407 transactions through 2009. Because 2009 transactions continued to be indicated throughout 2010, the 2009 transactions currently in the database were excluded from the analysis. The full data set 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.

TABLE 13.1
Water Transfer Prices by Sector, 1987–2008 (in 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 database, http://www.bren.ucsb.edu/news/water_transfers.htm.

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 a perpetual bond, a single committed quantity is calculated. With this discounted quantity, the total sales price is converted into a price per acre-foot that is directly comparable to a one-year lease price per acre-foot. Multiyear lease prices are treated similarly, using the same method as that for finding the present value of a multiyear bond, and are combined with one-year leases in table 13.1. Historical use patterns indicate that as much as 90 percent 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.

As shown, the annual mean and median sale and lease prices for agriculture-to-urban transactions are significantly higher than those for agriculture-to-agriculture trades (see the statistical discussion that follows). 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 with 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 13.1 shows the patterns of agriculture-to-agriculture and agriculture-to-urban median prices over time for sales and one-year leases. A Wilcoxon signed-rank test was performed,[8] and the yearly median price of agriculture-to-urban

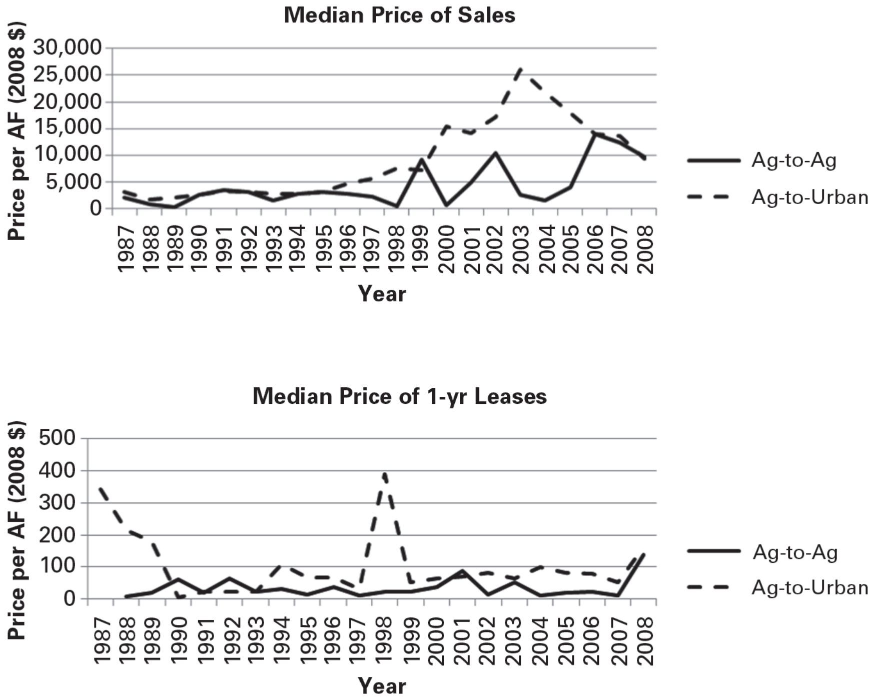
[5] All prices were converted into dollars per acre-foot of water for comparison across time. Prices for one-year transactions were easily presented in acre-foot terms. For example, if 1,000 acre-feet of water were leased for one year for a total price of $100,000, then the price per acre-foot was $100.

[6] Consider a sale of 1,000 acre-feet of water for a total price of $2 million. The price per acre-foot 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, discounting the quantity flows by 5 percent leads to a discounted sales price of $100 per acre-foot.

[7] http://www.ers.usda.gov/Briefing/wateruse/. U.S. Department of Agriculture, 22 Nov 2004.

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

FIGURE 13.1
Prices over Time



SOURCE: Author's calculations from database, http://www.bren.ucsb.edu/news/water_transfers.htm.

transfers is greater than that of agriculture-to-agriculture transfers at a 1 percent significance level.[9] In the database, agriculture-to-urban sales are dominated by transactions in Colorado on the Colorado–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.

There are two primary reasons that 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 database used here. The entire 22-year database reports only 613 agriculture-to-agriculture trades for the 12 western states. Brozovic, Carey, and Sunding (2002) report that in the Westlands Water District alone, where active intradistrict trading takes place, 1,267 transactions occurred from 1993 to 1996. The

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

[10] The Colorado–Big Thompson Project's institutional details are discussed later in this chapter.

[11] Of the 2,765 priced transactions used in this analysis, 215 were agriculture-to-agriculture sales, 32 of which were outside Colorado. In contrast, there were 1,140 agriculture-to-urban sales with price data, with 211 taking place outside Colorado.

second reason is that irrigators in western states often rely on leases instead of sales. 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 one-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 agriculture-to-urban leases is greater than that of agriculture-to-agriculture transfers at a 1 percent significance level.[12]

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 reallocating some water from agriculture to urban and environmental uses. Here an attempt is made to model what some of these gains might look like. The obstacles to modeling the efficiency advantages of water trades fall into three broad categories. The first is 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.[13] The second is the transaction costs associated with differing regulations and incomplete property rights regimes across jurisdictions. Regulations vary by state, and there can be county restrictions on transfers within states. The third is limited data. Water markets are local because of conveyance costs and regulatory restrictions. Therefore, they are thin, so there are limited observations of transfers and prices, and these data can be affected by observations that are not indicative of general patterns.

Figure 13.1 shows that agriculture-to-agriculture sales prices approximated agriculture-to-urban prices from 2006 to 2008. The high-priced agriculture-to-agriculture sales in 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/AF and from an irrigator to another irrigator for $9,626/AF.

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 the urban sector. Two cases are considered: (1) transfer of just a small amount (1 percent) of current irrigation water or 10 percent of the current urban market, whichever is smaller, to urban use; and (2) transfer of 3 percent of irrigation water or 100 percent of the current urban market, whichever is smaller, to urban use. These constraints are designed to minimize any impact on agricultural or urban sector water prices

[12] $W = -158$, p-value $= 0.003$.

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

and to reflect what might be feasible for an urban market to absorb.[14] Kenny et al. (2009) provide estimates of the total and irrigated use of water in the United States by state, and the Bren database, http://www.bren.ucsb.edu/news/water_transfers.htm, allows for trading estimates.

The state data are reported in table 13.2, which provides estimates of total surface water used and of water used in irrigation as of 2005, as well as the average committed volume of water transferred per year through all trades (sales, multiyear leases, and one-year leases) and that figure as a share of total use and irrigation use.[15] The final column lists the median price difference between agriculture-to-urban and agriculture-to-agriculture transfers.

Table 13.3 outlines the hypothetical transfers. Note that the volume of water in the proposed additional transfers is small compared with the water used for irriga-

TABLE 13.2

Surface Water Use (2005) and Average Water Trading Volume, Western United States, 1987–2008

	Surface Water Use (2005)		Current Total Water Transferred per Year (Committed)[a]			Median Price Difference (Agriculture-to-Urban minus Agriculture-to-Agriculture)
State	Total (AF)[b]	Irrigation (AF)	Average Volume (AF)[c]	As % of Total Use	As % of Irrigation Use	
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	

SOURCE: Author's calculations from database, http://www.bren.ucsb.edu/news/water_transfers.htm.

[a] Using committed amounts makes sense because they reflect 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).

[b] Kenny et al. (2009) provide estimates of the total use and irrigated use of water in the United States by state, and the Bren dataset allows for trading estimates by author. This category excludes water used for thermoelectric cooling but includes surface water use for public consumption, agriculture (irrigation, livestock, and aquaculture), industry, and mining.

[c] Average volume is the sum of all committed flows transferred in each year, averaged over the 22-year period recorded in the database. Because transactions often are for multiple years, the data here are calculated by the author to reflect longer time horizons. If one says that 10,000 AF was transferred in 2008, the meaning is that the discounted sum of committed flows for the duration of the transaction was 10,000 AF in 2008 because some of the flows were actually transferred in later years. This allows for a consistent treatment of prices.

[14] The additional transfers are assumed to 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.

[15] As was discussed for table 13.1, all contracted amounts of water are converted to a similar committed flow.

TABLE 13.3

Potential Gains from Increased Agriculture-to-Urban Transactions

State	Current Average Annual Market Value (All Transfer Types and Sectors)[a]	Proposed new Agriculture-to-Urban Transfers (AF)[b]	Net Welfare Gain from Additional Transactions[c]	Net Welfare Gain as % of Current Market Value	Proposed Agriculture-to-Urban Transfers (AF)[d]	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

NOTE: Differences that occur in the table are the result of rounding.

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

[b] One percent of surface irrigation water in AZ and TX and 10 percent of current agriculture to urban market for CA, CO, MT, NV, NM, OR, UT, WA, and WY.

[c] Net welfare gain is price difference (agriculture-to-urban minus agriculture-to-agriculture) multiplied by volume of additional transfers.

[d] Transfer minimum of 3 percent of irrigation volume or 100 percent of current urban market volume, whichever was smaller. The large welfare gain shown in Colorado likely reflects the difference in high prices paid for water within the Colorado–Big Thompson District discussed in the text.

tion or with total current transfers. Column two shows the value of current water transfers; column three the proposed increase under option (1); the associated welfare gains and its share of current transfers are in columns four and five, the increases under (2) are in column six, and the associated gains are 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 percent and 24 percent, respectively, of the value of the yearly water market activity of almost $406 million. Even under the conservative conditions imposed in this exercise, there appear to be significant annual welfare gains from increased movement of water from agriculture to urban uses. Any increases in trading are constrained by the existing size (already small) 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 of agriculture-to-agriculture trades in the database. Nevertheless, they indicate the potential benefits of a more active water market.

Water Transfers in 12 Western States, 1987–2008

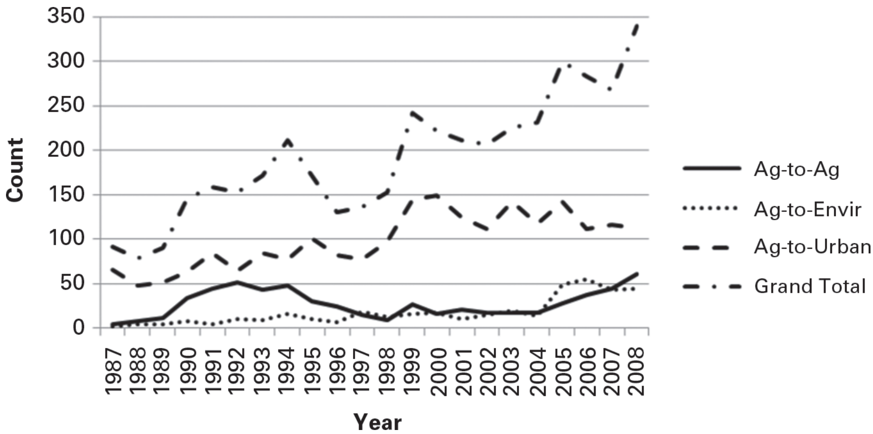
All western states allow for transfers of water. There are three types of transfers: permanent sales of water rights, short-term leases (one year), and longer-term leases (up to thirty-five years or more). Transfers occur among those who use the water for the same purpose (e.g., irrigated agriculture) or for different purposes (agriculture-to-urban or environmental); they also occur within a water basin (where sources are interrelated geologically) or across basins (from one water region to another). Transfers by 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 the use of water.

Figure 13.2 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 paths in the figure indicate 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 discernible trend (statistically insignificant).[16]

Table 13.4 shows the nature of trades across states and by contract form from 1987 through 2008. Colorado dominates total market transactions, reflecting the institutional advantages of the Colorado–Big Thompson Project (CBT), which are described later and and within the CBT most of the transactions are sales. Other active market states are California, Texas, Arizona, and Nevada. Within California and Texas, short-term leases are the most prevalent contract, but multiyear leases and sales are also important. California's institutional and regulatory environments for water explain the focus on short-term leases. In Arizona and Nevada, which are

[16] Although Colorado dominates the number of transactions, the trends remain the same in direction and statistical significance when Colorado transactions are removed.

FIGURE 13.2
Number of Transfers in 12 Western States, 1987–2008



SOURCE: Author's calculations from database, http://www.bren.ucsb.edu/news/water_transfers.htm.

TABLE 13.4
Water Transactions by Type and State

	Number of All Transactions	Number of Sales	Number of Short-Term Leases	Number of Long-Term Leases
Arizona	233	158	46	12
California	656	108	317	77
Colorado	2,144	1,804	97	43
Idaho	148	31	107	3
Montana	46	3	14	26
New Mexico	153	73	59	15
Nevada	192	148	4	4
Oregon	125	24	56	25
Texas	320	91	141	71
Utah	84	61	15	7
Washington	57	24	23	9
Wyoming	62	6	41	5
Total	4,220	2,531	920	297

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.

Table 13.5 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 committed amounts. Again, there are important differences across the states. Among the leading water-trading states, Arizona and California have relatively balanced transactions across sectors, but Colorado, Texas, Nevada, and Washington show considerable activity (a relatively high level of trades) to and within the urban sector.

TABLE 13.5
Share of Each Transfer's Classification in 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 database, http://www.bren.ucsb.edu/news/water_transfers.htm.

It is clear that 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. The answer begins with an examination of 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 suggests the special nature of water. The state owns the water and holds it in trust for its citizens. Individuals hold usufruct rights to the water, subject to the requirement that the use be beneficial and reasonable, but the state has the authority to monitor use and water transfers to ensure that they are consistent with the public interest (Gould 1995; Simms 1995). Accordingly, there is a broad regulatory framework for water, and western water rights potentially have less protection and are more fragile than most other property rights (Gray 1994a; Sax 1990).

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 watercourse for beneficial purposes on land remote from the point of diversion (Getches 1997). The appropriative doctrine emerged in the nineteenth century in response to the development of mining and agriculture in the semiarid 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, Gisser, and Werner 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 (surface water or groundwater), 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. Therefore, there is a ladder of rights on a stream. This allocative mechanism ranks competing claimants by priority in order to ration water during times of drought. 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).[17]

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). During times of drought, when only senior appropriators may have their allotments fulfilled, junior appropriators are especially dependent on these return flows. They bear most of the downside risk of drought. Actions by senior rights holders that affect water consumption 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 ensure that no harm is inflicted on junior diverters (Getches 1997).

Riparian Surface Water Rights

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

Of the 12 western states examined in this chapter, the wettest states, California, Texas, Oregon, and Washington, have a hybrid of prior-appropriation and riparian systems, whereas the drier states have prior appropriation only (Getches 1997). When both systems operate, there can be questions of priority of claim when diversion under the prior-appropriation 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 they are given precedence in California in disputes with appropriative claimants under certain circumstances (Getches 1997).

[17] See Anderson and Johnson (1986) and Johnson, Gisser, and Werner (1981). Johnson, Gisser, and Werner describe how specifying a property right in water in terms of consumptive use with options for third-party grievances can be an effective method of promoting transfers. Howitt and Hansen (2005) and Smith (2008) discuss water rights and water regulation across the states.

Groundwater Rights

Groundwater rights vary across the western states, and most are less well defined than are surface water rights (Thompson 1993). Most groundwater rights allow owners of surface land access to a reasonable use of groundwater (Getches 1997). 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 (Glennon 2002; Provencher and Burt 1993).[18]

These are the basic water rights in the western United States. 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

Because of water's fluid nature and the fact that many parties use it sequentially or simultaneously, there are significant resource and political costs in defining private water rights. 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.[19] Table 13.6 lists the three resources and their characteristics: ability to bound, partition, and exclude; ability to measure size and amount; variability of supply; and existence of simultaneous and sequential uses. The signs reported in each cell indicate how the characteristic affects the costs of definition of property rights for the resource; a plus sign indicates that it contributes to definition, while a negative sign indicates that it hinders definition. As can be seen, water is more like migratory fish stocks than it is like land with regard to the costs of bounding, exclusion, and measurement.

Costs of Bounding

Because surface water and groundwater are liquids, they 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 (Hannesson 2004). Ownership of 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 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.

Costs of Measurement

Fluidity and, in the case of groundwater, the lack of observability also raise the costs of measuring a water right. For this reason, ownership is based on the amount diverted

[18] For similarities with oil pools, see Libecap (1989).

[19] For discussions of the bundle of property rights in land, ease of monitoring boundaries, and partitioning land across private and public uses, see Ellickson (1993).

TABLE 13.6
Resource Characteristics

Resource	Ability to Bound, Partition, Exclude	Ability to Measure Amount	Variability of Supply	Simultaneous Uses	Sequential Uses
Land	+	+	+	+	+
Fish stocks	–	–	–	–	–
Water	–	–	–	–	–

or pumped (Johnson, Gisser, and Werner 1981). The amount actually diverted, however, varies over time because of 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 and adds 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 harvesting in ways that are often poorly understood. As a result, rights to fish or catch shares, such as individual transferable quotas, are based on the percentage of the annual allowable catch, not on a fixed amount of fish.[20] In contrast, there is no comparable problem for measuring fixed, observable land plots, where rights can be well defined with more certainty.

Interconnected Private and Public Goods Characteristics of Water

Because water diverters sequentially access the same (unconsumed) water and because associated amenity, riparian, and aquatic habitat values are often simultaneously supplied, private and public water uses are intertwined to an extent not found for land or fish stocks (Hanemann 2006; Smith 2008). 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 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, and Preferential Uses

Appropriative water rights are conditional on 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 whether

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

there was excess water to be assigned. Most western states define beneficial use generally as 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 as public values, judicial interpretations, and constituent-group politics change. For example, leaving water in-stream for habitat preservation recently has been accepted as a beneficial use across the states, although its exact definition differs among them (Getches 1997).[21]

The vague concept of beneficial use provides the basis for a potentially broad regulatory mandate (Getches 1997). Therefore, the determination of beneficial use and diversion requirements consistent with it makes water rights vulnerable to shifting legal and political interpretations and adds uncertainty to the water right. Historically, physical diversion and complete use of diverted water were deemed consistent with the doctrine and with maintenance of a water right, but this approach 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. Any conserved water could be interpreted as evidence of a lack of beneficial use of the past allotment and therefore could be subject to claims by other diverters (Getches 1997).

The No-Injury Rule (Third-Party Effects) and Area-of-Origin Restrictions

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. 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 affect release flows must be approved by state regulatory agencies. Petitions for trades must specify the amount of water involved, the duration of the contract, the timing of the exchange, the type of water right, the amount of 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 can be approval, approval

[21] See Anderson and Johnson (1986) and Scarborough (2010) for more discussion on in-stream flow rights.

subject to modification, or denial, as well as provision of opportunities for appeal (Colby 1995).[22]

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 be less straightforward. If substantial amounts of farmland are fallowed, there could be a 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 these issues are likely to be controversial, and they potentially weaken water rights and reduce the gains from water reallocation.[23]

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 lead 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. More important, under current law and political practices, they 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.

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. There are also monetary and efficiency benefits from the sale and more efficient use of water (Hanak 2003; Howitt 1994). Hanak (2003) points out that fallowing irrigated farmland is likely to have no more than a 1 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 on how the problem is interpreted legally and on the range for objections. If third-party impairment is strictly defined and limited to downstream junior rights holders who would be directly affected, 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 because of the differential complexity of water supply and use and in part because of different supply

[22] See also Colby (1990) and Colby, McGinnis, and Rait (1989).

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

and demand conditions. Two examples illustrate the process of regulation within the states.

California generally has protransfer 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 1994b). 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 (Gray 1990; MacDonnell 1990). Because there are 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 and trigger a regulatory review. The SWRCB also can deny a proposed water transfer if it would "unreasonably affect the overall economy of the area from which the water is being transferred" (California Water Code § 386). As a result, the administrative process of transferring water in California can be lengthy and complex, and the outcome can be 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 the 58 counties had done so (Gray 1994b; Hanak 2003; 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 on pumping. Although there are legitimate groundwater issues at stake, recent research by Hanak (2003) 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 the regulatory structure for the Northern Colorado Conservancy District that manages Colorado–Big Thompson (CBT) water differs from that 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 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 with 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 districtwide. Because shares are homogeneous, transfers across users, especially across sectors, occur with minimal fees and paperwork (Carey and Sunding 2001; Thompson 1993). In effect, the CBT has a cap-and-trade framework and has by far the most active water market in the West in terms of numbers of trades. Sale 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.[24]

[24] For example, sample agriculture-to-urban and agriculture-to-agriculture sales were priced at $9,350 and $9,300 per unit, respectively, as reported in the *Water Strategist* (October 2008, 7). The CBT also has the advantage

Public Resource, Public Interest, and Public Trust

For many persons, water is so critical and its uses are so complex that there are calls for it to be a public resource: "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" (Bates et al. 1993, 185). Similarly, Dellapenna argues that the best option is to "treat water as inherently public property for which basic allocation decisions must be made by public agencies" (2005, 35).

To the extent that these equity demands are based on the public goods nature of water, 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 (Bretsen and Hill 2009). If, 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.[25]

As the public interest is expanded to include a broader 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, as is underscored by the persistent differences in water prices indicated in table 13.1 and figure 13.1.

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 nonmarket values. Under those circumstances, water could be purchased by state agencies or nongovernmental 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 such transactions is that the opportunity cost of water becomes clearer. This information affects the behavior of both 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 made by the state and the political process. The record of state regulation of open-access fisheries is not one of success, and privatization of fisheries has resulted in significant rebounds of the stock (Costello, Gaines, and Lynham 2008). Whether the same result would apply for water remains to be

of using water stored in reservoirs, imported from elsewhere, a less complex case than when flowing streams are the water sources (Howitt and Hansen 2005, 60).

[25] 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 Mahan (2004).

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 (Becker 1983; Peltzman 1976). 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 that creates the legal right of the public to use 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). Under this 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 (Blumm and Schwartz 1995; Sax 1990; Simms 1995).

Because water is a mixed resource that provides private and public goods, there can be justifiable concerns about private water use that potentially harms 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. Such intrusion can add uncertainty to water ownership and weaken 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, and state, federal, and international management organizations.

State Regulatory Agencies, Water Supply Organizations, and Indian Tribes

The role of state regulatory agencies that must approve water transactions has already been discussed. Additionally, there are approximately 1,127 water supply organizations across 17 western states.[26] These institutions vary widely in 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, and 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 (Bretsen and Hill 2009).

For example, the governing boards of irrigation districts, the most common type of water supply institution, can be elected by district members (often land owners) or by broader community-wide 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 Irrigation District (PVID) and the Imperial Irrigation District (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 publicly elected boards, members may be much less interested in selling or leasing water under their jurisdiction than are landowners (Eden et al. 2008; Rosen and Sexton 1993; Thompson 1993). The PVID board reached agreement to fallow land and transfer water for urban use with little controversy, whereas the IID board was mired in lengthy, complex negotiations.[27]

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 United States and provides irrigation water for 140,000 farms covering 10,000,000 acres in 17 western states. It has more than 600 dams and reservoirs to capture and divert water, historically, mostly for irrigation.[28] The bureau provides water to irrigation districts through long-term service contracts. It 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 on water transfers (Thompson 1993). It also can arbitrarily adjust water deliveries to farmers in response to competing demands, such as those 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 and reduces their incentives for wise use and transfer (Bretsen and Hill 2009).[29]

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 the establishment of the reservation

[26] Water User's Organization Roster, U.S. Department of the Interior, Bureau of Reclamation, http://www.usbr.gov/uc/water/users/roster.pdf—as well as state agency Web sites; Leshy (1982).

[27] Glennon (2009), Haddad (2000), Hanak (2003), Northwest Economic Associates (2004), and Thompson (1993) discuss the Imperial Irrigation District's negotiations with San Diego and the Metropolitan Water District.

[28] U.S. Department of the Interior, Bureau of Reclamation, http://www.pvid.org/; http://www.usbr.gov/main/about/.

[29] Bretsen and Hill (2009) point out that in 1993, when the bureau cut deliveries to the Westlands Water District by 50 percent to meet environmental needs, the Ninth Circuit Court of Appeals ruled that the agency had not breached its contract with the district.

by treaty with the federal government, usually in the nineteenth century, and therefore generally supersede the priority of non-Indian claimants. Many of these treaty provisions have been enforced only recently, and Indian water rights have been adjudicated through litigation or confirmed by 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.

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 semiarid regions where increasing scarcity of fresh water is raising pressures for more efficient water use and management, as well as making greater equity demands.

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

Critics of appropriative water rights and water markets explicitly outline market failure. There is not, however, a similar level of precision in defining how the political, judicial, and administrative processes will function to manage and distribute water effectively, let alone address equity concerns, to meet growing challenges regarding this resource. 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 about 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.

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