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Why Water Markets Are Not Quick Fixes for Droughts in the Western United States

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CONTENTS

WATER RIGHTS AND MARKET-BASED REALLOCATION

In the western United States (Arizona, California, Colorado, Idaho, Kansas, Montana, North Dakota, Nebraska, New Mexico, Nevada, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming), water rights are based on appropriations of a fixed amount of water from a river for beneficial use, essentially putting a public resource to private use. In times of shortage, claims on surface water are satisfied in the order in which they were established: the longest-standing (senior) claims are completely filled at the expense of more recent (junior) claims, although the latter are protected from enlargement of existing rights or other changing uses that would affect existing claims. Water rights can also be transferred. Western water rights define an ownership interest that has characteristics similar to traditional notions of property rights (Anderson and Snyder 1997).

The prevailing view of property rights is that they are a collection of relationships between property owners and society at large that define or constrain what may be done with an item of private property (Penner 1996). The metaphor often used to describe property rights is a “bundle of sticks” (di Robilant 2013). The bundle represents the collection of liberties, claim-rights, powers, and immunities that define what it means to own property (e.g., right to possess, right to manage, right to security, liberty to waste or destroy) (Honre 1961). Because the bundle of sticks is well defined and transferable, property rights also provide the basis for market exchanges. Thus, by treating water in the western United States as property, markets are viewed as an effective instrument to reallocate water to the highest-valued uses.

Developing new water rights to keep pace with population growth in urban areas of the western United States is increasingly difficult. Since the 1970s, economists, environmentalists, and others have called for water rights markets for three reasons (Hartman and Seastone 1970; Johnson et al. 1981; Anderson 1983; Howe et al. 1986; Roos-Collins 1986; Saliba 1987; Gould 1988). First, water is more economically valued in urban settings than in agricultural settings, suggesting that farmers could often make more money selling their water to cities than they could selling their crops. Studies have estimated municipal wholesale prices to be anywhere from eight times to tens of thousands times higher than agricultural water values for comparable water (Brewer et al. 2008). Second, market transactions have been used for environmental protection by retiring irrigation water to create instream flows (Landry 1998; Neuman 2004). Third, governments have recognized the potential for market transfers. The U.S. Bureau of Reclamation (BOR) identified market-based transfers as “an important tool for resolving imbalances” in supply and demand of Colorado River water (BOR 2012, 82), and it is the policy of the Western Governers Association that states should promote voluntary water transfers from agricultural to other uses (Western Governors Association 2012).

Despite the rhetoric, market transfers of water rights from agriculture users to urban or environmental uses have been relatively few (Young 1986; Brajer et al. 1989; Dellapenna 2005). These transfers face two hurdles that complicate water markets: third-party effects and irrigation institutions. The third-party effect arises because one user’s “bundle of sticks” must be disentangled from many other users’ bundles before a water right can be transferred. Irrigation institutions create the effect of multiple users claiming shared ownership of a right, as if several hands were all legitimately gripping one bundle of sticks. These inescapable hurdles reflect the hydrologic and institutional connectedness of water users, arise because of the method by which property rights in water are defined, and create transaction costs that add time and money to any water transfer.

INTERTWINED BUNDLES OF STICKS

Nearly all of the prior appropriation water rights involve diverting water for off-stream uses, but only some of the diverted water is actually consumed, while the remainder is returned to the river. Water is “consumed” through evaporation; incorporated into plants, animals, or manufactured products; or exported into a different watershed. The water diverted but not consumed is returned through a sewer outfall, drainage ditch, or groundwater flow and is available for use by downstream users. Diverters with low consumptive use (relative to total diversion) are more hydraulically connected to downstream users than those with high consumptive use because a larger portion of their diversion may already be “spoken for” by downstream users. Changes to a water right can affect the water that another downstream user already has a claim on, effectively connecting the two rights and entangling their bundles of sticks.

The amount of diverted water actually consumed, or entanglement of bundles of sticks, varies by use. In the western states, thermoelectric power generation using once-through cooling technology consumes less than 5% of water diverted for that purpose (Figure 1, Table 1). Municipal, household, commercial, and industrial uses account for just over one-quarter of all diversions but also consume very little of the water diverted (14%). Agriculture accounts for the largest amount of water diverted. Regionally, 67% of diversions go to agriculture, but in some states, agriculture accounts for as much as 97% of diverted water. However, irrigated agriculture only consumes slightly more than half of the water that it diverts. The most consumptive use is thermoelectric power generation using closed-loop cooling technology. Although this use consumes nearly 70% of its diversions, it accounts for only 2% of regional diversions. Overall in the western United States, only 69 million acre feet (MAF) of the 141 MAF diverted is consumptively used.[1] More than half the water diverted under prior appropriation ends up returned to rivers, potentially to be diverted by other downstream users, effectively creating hydrologic connections among water users.

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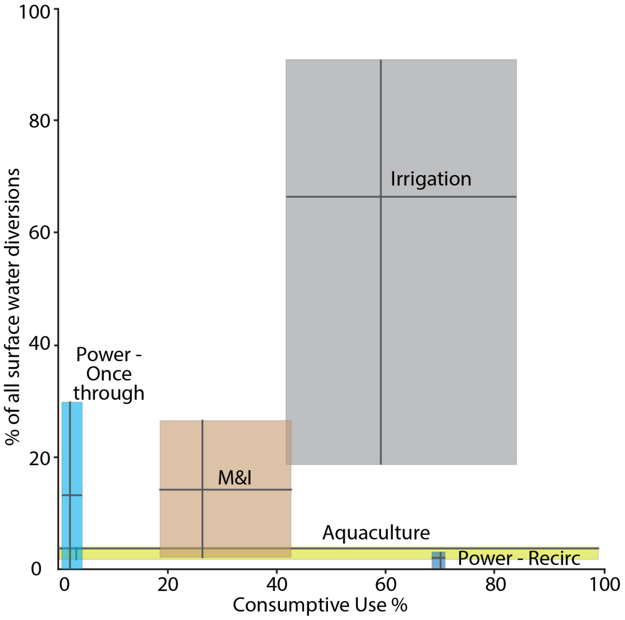
[1] An acre-foot is the common unit of volume reference in western water and is equal to 325,851 gallons or 1,233 cubic meters.

Figure 1. Ranges of Consumptive Use by Sector in the Western United States.



Sources: Data from USGS 2009; USGS 1998; and Averyt et al. 2013. See Table 1 for the data used to create this figure.
Note: The crosses indicate the regional consumptive use and percentage of surface water use accounted for by each use type. The boxes indicate variability among the 17 states and show the interquartile range of the consumptive use percent and the percent of surface water from the states. M&I (municipal and industrial) includes municipal, household, commercial, and industrial uses.

Table 1. State-by-State Breakdown of Amount of Water Diverted and Consumptively Used by Different Sectors.

	Total	Municipal,Household, Commerical, and Industrial[a]		Irrigation		Aquaculture		Thermoelectric Cooling (Once Through)		Thermoelectric Cooling (Reciruculating)	
	Fresh-water diverted (con-sumed) (*MAF*)[b]	% of total sur-face water use	% of freshwater diverstions consump-tively used[c]	% of total sur-face water use	% of freshwater diverstions consump-tively used[c]	% of total sur-face water use	% of freshwater diverstions consumptively used[c]	% of total sur-face water use	% of freshwater diverstions consump-tively used[c]	% of total sur-face water use	% of freshwater diverstions consump-tively used[c]
Arizona	6.1 (3.4)	56%	19%	79%	56%	0.070%	100%	0%	4.5%	1.2%	67%
California	32 (23)	26%	26%	71%	81%	2.1%	20%	0%	0.64%	0.18%	83%
Colorado	12 (4.7)	28%	8.2%	90%	39%	0.64%	0%	0.64%	3.4%	0.41%	69%
Idaho	12 (3.9)	2.4%	0.32%	84%	33%	16%	0%	0%	0%	0%	71%
Kansas	4.7 (3.2)	59%	30%	14%	95%	0.38%	92%	49%	3.9%	3.9%	68%
Montana	7.9 (1.7)	36%	1.1%	97%	21%	0.40%	100%	0.62%	0.69%	0.29%	68%
Nebraska	9.4 (6.3)	44%	1.9%	24%	89%	1.5%	7.6%	72%	1.5%	0%	68%
Nevada	2.0 (1.2)	40%	39%	59%	64%	0.048%	0%	0%	0.66%	1.5%	69%
New Mexico	3.1 (1.8)	56%	2.4%	93%	56%	1.1%	0%	0%	4.5%	2.7%	69%
North Dakota	1.0 (0.16)	34%	3.8%	6.1%	90%	0.52%	0%	87%	4.0%	2.2%	69%
Oklahoma	1.6 (0.64)	18%	56%	14%	46%	1.9%	0%	2.8%	4.2%	14%	70%
Oregon	7.0 (2.9)	6.2%	12%	74%	50%	13%	100%	0%	4.5%	0.15%	77%
South Dakota	0.41 (0.22)	19%	15%	62%	65%	6.1%	0%	0%	4.5%	1.7%	68%
Texas	22 (9.4)	29%	26%	11%	86%	0.058%	98%	52%	3.5%	9.3%	71%
Utah	3.8 (2.0)	35%	7.0%	91%	55%	0.005%	0.56%	0%	0%	1.1%	69%
Washington	7.9 (2.7)	13%	19%	69%	43%	0.74%	100%	10%	0%	0.72%	66%
Wymonig	6.3 (2.5)	41%	1.2%	92%	40%	0.54%	6.4%	4.2%	0.69%	1.5%	68%
Region	141 (69)	26%	14%	67%	59%	3.6%	3.2%	13%	2.0%	1.9%	70%

	Surface water diverted (*MAF*)[d]	Surface water diverted (*MAF*)[d]	Freshwater diverted (consumed) (*MAF*)[e]	Surface water diverted (*MAF*)[d]	Freshwater diverted (consumed) (*MAF*)[f]	Surface water diverted (*MAF*)[d]	Freshwater diverted (consumed) (*MAF*)[g]	Surface water diverted (*MAF*[h]	Freshwater diverted (consumed) (*MAF*)[g]	Surface water dierted (*MAF*)	Freshwater diverted (consumed) (*MAF*)
Arizona	3.5	0.67	0.74 (0.41)	2.9	5.1 (2.8)	5.1	0.0005 (0.0005)	0	0.10 (0.005)	0.044	0.26 (0.17)
California	25	6.5	5.4 (1.4)	18	26 (21)	26	0.14 (0.028)	0	6.3 (0.040)	0.045	0.11 (0.088)
Colorado	12	1.0	0.69 (0.19)	11	11 (4.4)	11	0.013 (0)	0.080	0.16 (0.006)	0.051	0.10 (0.072)
Idaho	17	0.05	0.52 (0.01)	14	12 (3.8)	12	1.2744 (0)	0	0 (0)	0	0.003 (0.002)
Kansas	0.94	0.28	0.34 (0.20)	0.13	3.0 (2.9)	3.0	0.0024 (0.0022)	0.46	0.89 (0.035)	0.037	0.071 (0.049)
Montana	11	0.12	0.16 (0.06)	11	7.6 (1.6)	7.6	0.0008 (0.0008)	0.069	0.15 (0.001)	0.032	0.052 (0.036)
Nebraska	5.5	0.11	0.30 (0.13)	1.3	6.7 (6.0)	6.7	0.023 (0.0008)	4.0	0.92 (0.014)	0	0.055 (0.037)
Nevada	1.6	0.61	0.42 (0.17)	0.93	1.5 (0.94)	1.5	0.0005 (0)	0	3.4 (0.022)	0.024	0.010 (0.007)
New Mexico	1.9	0.04	0.30 (0.17)	1.7	2.7 (1.5)	2.7	0 (0)	0	0.55 (0.025)	0.051	0.050 (0.035)
North Dakota	1.3	0.05	0.07 (0.02)	0.08	0.10 (0.09)	0.10	0.0006 (0)	1.167	0.052 (0.002)	0.030	0.025 (0.018)
Oklahoma	1.1	0.62	0.54 (0.10)	0.15	0.77 (0.36)	0.77	0.0007 (0)	0.031	0.40 (0.017)	0.15	0.13 (0.087)
Oregon	5.7	0.70	1.5 (0.09)	4.2	5.5 (2.7)	5.5	0.0005 (0.0006)	0	0.15 (0.007)	0.008	0.014 (0.010)
South Dakota	0.26	0.04	0.09 (0.02)	0.16	0.24 (0.16)	0.24	0 (0)	0	0.13 (0.006)	0	0 (0)
Texas	18	4.6	4.7 (1.4)	1.9	8.4 (7.3)	8.4	0.015 (0.015)	9.2	6.6 (2.3)	1.6	0.32 (0.23)
Utah	4.4	0.31	0.51 (0.18)	4.0	3.2 (1.7)	3.1	0.082 (0.0005)	0	0 (0)	0.050	0.12 (0.083)
Washington	4.7	0.89	1.7 (0.21)	3.2	5.8 (2.5)	5.8	0.0007 (0.0007)	0.48	0 (0)	0.034	0.044 (0.029)
Wymonig	4.4	0.05	0.08 (0.03)	4.0	5.9 (2.4)	5.9	0.0074 (0.0005)	0.18	0.37 (0.003)	0.067	0.11 (0.075)
Region	118	17	18 (4.8)	79	105 (62)	105	1.6 (0.050)	16	20 (0.41)	2.3	1.5 (1.03)

[a] Includes self-supplied water and water delivered through a public supply system.

[b] Annual amount of freswater withdrawals and freshwater consumptive use in 1995 (USGS 1995, Table 2).

[c] Percent of diverted water that is conusmed in a particular category.

[d] Amount of surface water diverted in 2005 (USGS 2009, Table 3).

[e] Amount of freshwater witdrawals and freshwater consumtive use in 1995 (USGS 1998, Tables 12, 14 ,20).

[f] Amount of freshwater witdrawals and freshwater consumtive use in 1995 (USGS 1998, Table 16).

[g] Amount of freshwater witdrawals and freshwater consumtive use in 1995 (USGS 1998, Table 18—animal specialities).

[h] Amount of surface water diverted in 2005 (USGS2009, Table 13).

[i] Annual amount of freshwater withdrawals and freshwater consumptive use for thermoelectric cooling was computed from the database reported in Averyt et al. (2013). Accessed from http://www.ucusa.org/clean_energy/our-energy-choices-energy-and-water-use/ucs-power-plant-database, April 23, 2013.

In recognition of these connections, states require a review to ensure that water transfers do not adversely affect a third party's water right. Economic third-party effects are those impacts of a transfer transmitted by economic channels, such as a decrease in taxable land value or decline in farm implement store revenue following a water right sale. Consideration of these third-party effects varies greatly from one water transfer to another, even within a single state. However, all states enforce protection from physical third-party effects—those that affect the actual availability of water required to fulfill an existing water right. Transferring a water right from an agricultural user to a municipality normally involves moving the point of diversion and changing the timing of the diversions, creating physical third-party effects on other users along the river.

Given that almost all water uses result in water return to streams, which are in turn used by subsequent users, any water transfer could cause third-party effects, and the requirement to investigate these effects may add several years and several hundred thousand dollars to even a small (few hundred acre feet) transfer.

MANY HANDS HOLDING A SINGLE BUNDLE

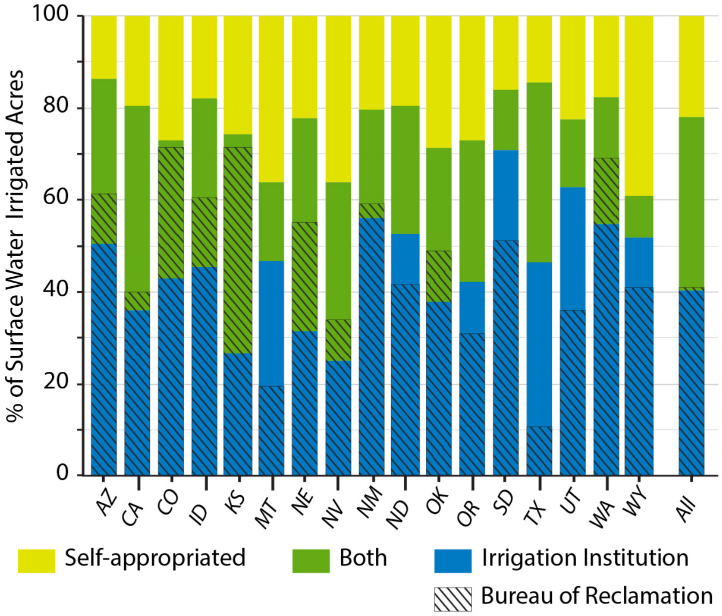
Multiple ownership claims arising from irrigation institutions create a second hurdle to water transfers. Water rights arise from two actions: diverting water from a natural watercourse and putting the water to a beneficial use. Where a farmer owns riparian land, digs a ditch, and uses the water to irrigate, he or she is the sole owner of the water right—he or she is the only one holding that particular bundle of sticks. However, much of the water used for western irrigation is delivered through an irrigation institution in which an organization diverts, stores, and delivers water to a farm whose owner puts the delivered water to a beneficial use. Both the institution and the farmer complete one of the two actions required for ownership of a water right, but the courts have recognized that regardless of who owns title to the water, all entities involved have a considerable role in the disposition of the water right (*Nevada v. United States* 563 U.S. 110, 126 (1983); *United States v. Imperial Irrigation District* 559 F.2d 509 (9th Cir. 1977); Benson 1996). The consequence is that one bundle of sticks can have multiple owners with legitimate claims to it. Before a bundle of sticks can be sold or transferred, it must be clear who holds the right to transfer that bundle; all of those holding the bundle must agree to the transfer.

Types and structures of irrigation institutions vary greatly, in part because of their evolution in response to the demands of the environment and changing economy (Bretsen and Hill 2006). In the mid-to-late 19th century, western agricultural settlement took place in riparian areas where a lone farmer could satisfy his or her farm's irrigation needs with minimal infrastructure. As agriculture expanded, irrigation water needed to be captured and stored to smooth out variations in need within and between years. Larger networks of canals were required to deliver the water to non-riparian agricultural lands. Eventually, a mismatch in optimal scales of water delivery and agricultural production occurred, making vertical integration of water delivery and farming into a single entity impractical. What developed were large institutions such as private "mutual ditch" companies, public districts (irrigation, conservation, conservancy, water supply, and so on, hereafter referred to as *irrigation districts*), and a federal agency (BOR) that could pool the capital necessary to develop large water storage and delivery projects. Farmers began to have water delivered through artificial ditches under contracted terms with a ditch company, irrigation district, or the BOR. Because the ditch, irrigation district, or BOR diverts water, and the farmer puts it to beneficial use, it is unclear exactly who "owns the water," and in many cases, the clearest answer is that several entities have ownership claims, or hands on the bundle of sticks (Benson 1996).

Agricultural water ownership in the modern West is in fact dominated by irrigation institutions, with self-appropriated water accounting for only 12%–39% of agricultural lands irrigated with surface water (Figure 2, Table 2). Between 22% and 78% of surface water-irrigated lands receive water from an irrigation institution, and many farms irrigate with a combination of self-appropriated and delivered water (Figure 2). Moreover, as a proportion of surface-water-irrigated farmland, BOR projects account for 30%–52% of that acreage. In all states except Montana, Nevada, and Wyoming, fewer than one-third of surface-water-irrigated farms receive no water from an institution. In contrast, in Arizona, New Mexico, North Dakota, South Dakota, Utah, Washington, and Wyoming, more than 50% of surface-water-irrigated farms receive water exclusively from an institution. Similarly, the BOR's influence is not uniform across the West. In Montana and Texas, BOR water irrigates less than 20% of surface-water-irrigated farmland. However, BOR water irrigates more than two-thirds of similar farms in Colorado, Kansas, and Washington.

Throughout the western United States, the bulk of irrigation water passes through some type of institution. There are therefore multiple ownership claims on irrigation water; the types of institutions involved vary. Transferring water with multiple ownership claims requires negotiating the transaction with the many interests involved, which increases the time and money required.

Figure 2. Amount of Surface-Water-Irrigated Farmland Irrigated with Self-Appropriated Water and Water Delivered through an Irrigation Institution.



Sources: Data from USGS 2009; USDA 2009a; and USDA 2009b. See Table 2 for the data used to create this figure.

Table 2. State-By-State Breakdown of Farmland Irrigated with Surface Water by Sources.

	All irrigated farmland	Farmland irrigated with surface water	Farmland irrigated with self-appropriated surface water		Farmland irrigated with surface water from an irrigation institution		Farmland irrigated with surface water from the USBR[6]	
	(1000 acres)[a]	(1000 acres)[b]	(1000 acres)[c]	% of all SW acres[d]	(1000 acres)[c]	% of all SW acres[d]	(1000 acres)[e]	% of all SW acres[d]
Arizona	860–950	500–730	50–130	8–26	310–550	42–110	360	50–73
California	7,330–9,050	2,980–5,820	290–1,430	5–48	1,190–3,220	20–108	1,570	27–53
Colorado	2,870–3,030	1,610–2,460	460–720	19–45	820–1,090	33–67	1,400	57–87
Idaho	3,300–3,530	2,120–2,750	370–610	14–29	1,100–1,550	40–73	1,450	53–68
Kansas	2,570–3,120	80–160	20–50	11–62	30–40	16–47	80	49–95
Montana	1,950–2,270	1,890–2,240	700–830	31–44	920–1,070	41–57	400	18–21
Nebraska	8,350–8,560	520–2,250	10–250	1–49	170–440	7–83	480	19–92
Nevada	580–690	320–500	160–270	31–86	100–160	20–51	130	26–42
New Mexico	830–870	290–480	60–100	12–34	210–290	45–101	210	45–74
North Dakota	240–260	80–130	20–20	14–27	60–60	44–73	40	34–50
Oklahoma	460–530	80–130	30–40	21–46	40–50	29–58	50	38–61
Oregon	1,760–1,970	1,300–1,510	370–540	25–42	590–810	39–62	440	29–33
South Dakota	360–420	150–210	20–20	9–15	120–130	60–86	90	43–59
Texas	5,101–6,210	670–1,340	60–160	5–23	460–610	34–90	100	7–14
Utah	1,070–1,210	910–1,090	210–240	19–26	620–690	57–76	360	33 – 39
Washington	1,680–1,840	1,240–1,510	220–310	15–25	750–940	50–75	940	62–76
Wymonig	1,000–1,550	890–1,430	540–610	38–68	720–810	50–90	450	32–51
Region	42,210–45,130	16,300–28,910	3,590–6,320	12–39	8,220–12,500	28–77	8,560	30–52

[a] Range of irrigated farmland encompasses the reported total irrigated acreage (USGS 2009, Table 7; USDA 2009, Vol. 3, Part 1, Ch. 1, Table 11; and USDA 2009, Vol. 1, Ch. 2, Table 10).

[b] Surface-water-irrigated acres is the range that encompasses (1) area estimated from USGS (2009, Table 7) by assuming a consistent water duty between surface water and ground water users, (2) area from USDA (2009, Vol. 3, Ch. 1, Table 11),subtracting acres using only groundwater as a source from total irrigated acres, and (3) area from USDA (2009, Vol. 3, Part 1, Ch. 1, Table 11), subtracting acres using any groundwater as a source from total irrigated acres.

[c] Range of irrigated acres reported in USDA (2009, Vol. 3, Part 1, Ch. 1, Table 11) as using only off-farm (on-farm surface) water and as using any off-farm (on-farm surface) water.

[d] The percentage of total surface-water irrigated acreage in each category is computed assuming no correlation between the numerator and denominator.

[e] The USBR-irrigated acres by state were estimated from the irrigated acres reported for each project at 222.usbr.gov/projects/. The apportionment of multi-state projects was estimated on the basis of the reported project area. Project-level data are available at http://sites.nicholas.duke.edu/charlespodolak/files/2014/04/BoR_Projects_by_State.xslx.

[f] The USBR reports delivering water to 10 million acres of farmland (http://www.usbr.gov/main/abount/), compared with 8.6 million acres by our accounting.

IMPLICATIONS

Addressing Third-Party Effects

The requirement to assess third-party effects is a government-imposed requirement in all western states. A common refrain from those advocating for water market reform is to reduce government interference (Gould 1988; Anderson and Snyder 1997). For instance, one proposal would allow a water user to own the entire amount that the user diverted, not just the amount consumptively used (Meyers and Posner 1971). This approach would remove third-party concerns, because no junior downstream user could claim to have rights to water that a senior user was justified to consumptively use. However, the approach would transform a central tenant of prior appropriation water law that one can earn a right to only as much water as one can beneficially put to use. Allowing a user to divert arbitrarily large quantities, to beneficially use a portion, and to continue to claim the remaining return flow could lead to hoarding, speculation, and monopolies. Altering the water rights system in such a way to define away third-party effects cannot be accomplished without fundamentally altering the basis of western water law.

A more viable approach is to acknowledge third-party effects but to improve the methods used by states to assess such effects. To that end, states could establish clear and consistent guidelines defining the level of certainty required by a party showing no third-party effects and outlining accepted methods to demonstrate the lack of effects. For instance, the Wyoming Board of Control requires that a proposed transferer demonstrate with "clear and convincing evidence" that no other water users will be injured by the transfer, even when there are no claims of injury (Gould 1988). In contrast, Colorado requires that a transferer need only to rebut claims of injury proposed by other water users (*City of Colorado Springs v. Yust* 249 P.2d 151 (1952)). The lower standard used by Colorado should place a lower third-party effects burden on transfers, and thus if applied across the western United States, it would increase the potential for water markets.

An additional approach would be for states to adopt standard assumptions and methods for consumptive use and return flow calculations (Western Governors Association 2012). One example for consumptive use standardization is Montana's codified standard assumption of evapotranspiration based on the location used in estimating historic consumptive use (Mont. Code Ann. §36.12.1902). Return flow calculations could be standardized using generally accepted methods of groundwater modeling and surface water interaction. This modeling is essential because much of agricultural return flow occurs through groundwater recharge, and transferees are required to maintain historic return flows. States could standardize the process by developing such a model or by adopting an existing one.

There is no getting around third-party effects on water transfers, although the process of evaluating the effects can be improved and streamlined. Yet even when more efficient, the process of addressing third-party effects will require an investment of time and money.

Addressing Institutional Effects

Most of the agricultural water in the western United States is delivered through an irrigation institution, creating multiple ownership claims on that water. Because there are multiple hands holding the bundle of sticks, transferring this water through markets requires negotiating the transaction with multiple parties. Whether dealing with a private ditch company or a public irrigation district, a transfer will be subject to approval of a governing board. An approval for a transfer of water outside an institution's boundaries can be a time consuming, expensive, and subject to broad community interests and influences. When a market transaction may be financially beneficial to an individual farmer, the governing board is often responsive to a broad set of interests, such as a local community that is dependent on continued irrigated agriculture, and may be hostile to any transfers. Because irrigation districts have a variety of voting structures, the relative importance of farmers' views vis-à-vis the rest of the community is quite variable. The economists McDowell and Ugone have shown variations in behaviors of irrigation districts based on their voting structure, and differences in voting structure have been used to explain the differences in water transfers between the Metropolitan Water District of Southern California's (Met) two southern California irrigation districts: the Imperial Irrigation District and the Palo Verde Irrigation District (PVID) (McDowell and Ugone 1982; Glennon 2009). Regardless of its internal structure, an irrigation organization is an additional fist on the bundle of sticks and, hence, another hurdle for a market transaction of water rights.

Multiple strategies have been applied, with various levels of success, to gain the necessary governing board approval. One is an outright purchase by an entity wishing to acquire irrigation water of enough property in a district or a ditch company to gain sufficient voting rights on the governing board to approve the transfer; this strategy has been referred to as the *hostile takeover strategy* (MacDonnell 1999). One case in which this strategy failed is the 1992 attempted buyout of the Fort Lyon Canal Company on the Lower Arkansas River, Colorado, by the Colorado Interstate Gas Company (MacDonnell 1999).
A second strategy is to gain board approval by providing community development funds that offset the potential negative economic impacts on the community associated with the water transfer. An example of this strategy is the $6 million contribution made by Met to a community improvement fund in the Palo Verde area to gain approval for water transfer from the PVID and "to offset any potential economic impacts from the (transfer) program."[2]

A third strategy involves rotational fallowing, in which many farmers fallow portions of their field rather than ceasing all farm operation. Although this strategy reduces the total amount of agriculture lands in production at any point in time, it may reduce the impact on the broad agricultural community because it keeps the same number of farms in operation over time. The aforementioned Met-PVID transfer also used this approach: willing participants could voluntarily fallow between 7% and 29% of their land in a given year for which Met would pay the landowner for each acre out of production. Met would then receive the water allotment that otherwise would have gone to irrigate the land (Glennon 1999).

These strategies to gain board approval have resulted in some successful transfers, yet there is risk that in the end the transfer will not be approved. Irrigators in the Lower Arkansas Valley have been attempting since 2003 to create a rotational fallowing program called the Super Ditch (following the example of the MET-PVID transaction); it has yet to come to fruition. Much of western irrigation water is tied up in one kind of institution or another; because of institutional hurdles, water transfers will require time and money and always be subject to political uncertainty.

CONCLUSION

Because of the peculiar nature of water rights, we should look to market-based transactions as a way to reallocate scarce water resources. Consequently, we need to accept that market transfers of water rights will take years, not because of onerous government regulations, but because of the need to untangle the hydrologic interconnectedness of water rights and the institutional connectedness of irrigators and delivery institutions.

Water in the western United States can be bought and sold, but the transactions will always be complicated. Transfers of water will always be expensive and time consuming because of the hydrologic and institutional interconnections inherent to water. Our data show that most of the water rights in the West are messy. Therefore, markets cannot be quick fixes, and using markets for future water allocation, even if it is economically efficient, will take time and resources to set up.

Untangling serial uses and negotiating multiple ownership claims are hurdles, not barriers, and they can be overcome in time but will require both time and money. Buying existing water rights may be less

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[2] See http://www.mwdh2o.com/mwdh2o/pages/news/at_a_glance/Palo-Verde-fact-Sheet.pdf, accessed June 11, 2014.

costly than building infrastructure to transport available water from long distances or desalinating seawater, but the transactions will come at a price. Municipalities may purchase water from farmers and thus bear the transaction costs directly, or the private sector may purchase agricultural water (e.g., Two Rivers Water and Farming, Colorado (Landry 2012)), bear the associated risk and transaction costs, and sell it on to municipalities. In either case, the end users will inevitably pay higher prices for water. Markets can and will be part of western U.S. water allocation, but they do not provide quick solutions. Droughts can focus public attention on the value of water and potentially increase the willingness-to-pay prices that reflect the transaction costs of tangled western water markets.

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