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Marketing the Colorado River: water allocations in the American Southwest

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Abstract The Colorado River is the lifeline of the American Southwest and its waters have been litigated, divided, and fought over for more than a century. One of the recent facts water users must face is that there is not enough water to meet all the demands. A growing water market in the west is one current way western states seek to reallocate water and address shortages caused by drought and over-consumption. The debate over water marketing, however, illustrates a divided opinion about how water should be allocated. Those advocating water marketing argue that commoditizing water will inevitably result in appropriate usage and conservation. Others argue that unintended impacts on third parties to water transfers makes them unreasonable. Most agree that some kind of mitigation of third party impacts must be part of any permanent water market and several different methods are currently used to address this issue. It is unclear what the long-term affects of marketing Colorado River water will be or whether it will prove itself an equitable system. One certainty is that finding new ways to allocate and conserve water in the west is vital to the region's present and future.

Keywords Water · Rivers · American Southwest · Colorado River · Water markets · Water banking

Among the various issues that dominate global policy discussions, water stands as one of the most pressing. As the population swells past the six billion mark, the scarcity of water now occupies probably more attention than most other environmental issues. In 2008, the award winning documentary film entitled *Flow* (*For the Love of Water*) directed by Irena Salina, demonstrated this worldwide interest. Proclaiming that the wars of the future would be fought over water, Salina highlighted the pressures of water scarcity and the effects of privatization. According to water experts interviewed, the commoditization of water is already wide spread and its continued growth is inevitable. In this paper, I examine the

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most developed water market in the United States in order to understand the seriousness of the water issue and how marketing affects it. First I examine how the water market in the southwestern United States works with a focus on the Colorado River watershed. I trace the development of this market over time, and then highlight the measurable costs and benefits. I conclude by addressing current challenges affecting water in the southwest and the impact of the market. Although there are significant problems in the marketing of water, this system could work to address growing water shortages in a fair and equitable way, but only with government regulations.

In many regions, the failure of publicly administered utility companies to adequately supply their constituents with clean and safe water has made it possible for private companies to grow and take over market-share within a wide variety of conditions. For over a decade, Australia has used a kind of water-market to address its own shortages between supply and demand. Since 1997, it has operated a water exchange through several entities (such as the National Water Exchange) that transact both temporary trades and permanent sales of water rights (Hadjigeorgalis 2008). Assessments of these exchanges seem generally positive, with analysts citing increased income for farmers who sold or leased water instead of growing crops.

Similar water exchanges have also been successful in Chile, India, Pakistan, and China, to name a few. Currently, China might face the worst water crisis worldwide with an ongoing drought that has steadily worsened since it began in 2009. As early as the mid 1990s, Chinese farmers informally marketed their water and after 2002, the government made significant efforts to treat and recycle wastewater as part of its growing water market (U.S. Dept of Commerce 2005). The questions in these countries are not about whether water should be marketed, but about where the water comes from and who reaps the benefits. As large water companies such as Suez, Vivendi, and Thames vie for market-share in far-flung places like India and South Africa, the discussion about the commoditization of water seems almost a moot point. Globally, water has undergone privatization for much of the 20th century.

Early scholarship on water marketing appeared as early as 1968 with Gardner and Fullerton's, article "Transfer Restrictions and Misallocations of Irrigation Water." Other works that focused on American experiments with marketing include Hartman and Seastone, *Water Transfers: Economic Efficiency and Alternative Institutions* (1970), Meyers and Posner, *Market Transfers of Water Rights* (1971), Burness and Quirk, "Water Law, Water Transfers, and Economic Efficiency: The Colorado River" (1980), Anderson, editor, *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment* (1983), and Vaux and Howitt, "Managing Water Scarcity: An Evaluation of Interregional Transfers" (1984). All of these authors argue persuasively that market forces will best regulate the price of water, thus encouraging water conservation. They also argue that necessary redistribution of water allocations can only be made fairly through a market. Recent works that promote water marketing include Anderson and Snyder (1997), Haddad (2000), and Robert Glennon (2005, 2009).

Still, other scholars voice concern that the growing southwestern water market will deprive some people of a basic right to water and have unintended impacts on 3rd parties (Ingram et al. 1986). In this paper, I seek answers to several questions. What are the long-term impacts of water marketing on the environment, agriculture, and urban populations? Who reaps the economic benefits and who loses? How can negative impacts of water marketing be addressed in order to preserve everyone's rights to water? Examining these issues in the American southwestern context can serve as a microcosm in which to seek answers to the global question dominating water marketing discussions: Can and should

water be considered a commodity that can be owned by the individual? Or, should water be preserved as unique; a social good not owned by any one person? Is there a middle ground between the two views? These are not simple questions and no single study will likely be able to answer them adequately for all circumstances. Yet, the example of water marketing in the American southwest seems to support its benefits, but only with important restrictions through government regulation. While a regulated market is not yet perfected, this study indicates that such a middle ground might actually be successful in conserving water and allocating it fairly.

In the United States, water still flows through public systems and into households at a fairly low cost, but there is a growing awareness of looming shortages, especially in the arid southwest. Here, water comes mostly from a few rivers that have been dammed and channeled to serve farmland and urban centers. One of the most important sources of water in this region is the Colorado River. Running through seven states in the U.S. and two in Mexico, this international river makes life possible in Los Angeles, San Diego, Phoenix, Tucson, Las Vegas, Denver, and south of the border in Mexicali. A little more than 2,330 km (1,450 miles) long, its main stem is controlled and stored by five major dams and dozens on its tributaries. From the early part of the 20th century, settlers in the southwest have drained more and more of the river's flow, dividing this precious water among the basin states with often contentious laws and compacts. Water quality and quantity issues have created international strains as well as agreements between the United States and Mexico. On both sides of the border, farmers vie for shares of a dwindling supply. Metropolitan areas have grown beyond what the river can reasonably support and unsettled indigenous claims to its water create additional demands on a meager resource. Ongoing drought and climate change add more pressures to this river that no longer reaches the sea. The story of the American water market experiment begins here with this over-tapped and over-allocated lifeline of the southwest (Fig. 1).

How the market functions

It is not particularly easy to trade or market a river's flow. Such an effort requires agreed-upon measurements and innovative exchanges. So far, the majority of southwestern water transactions have been conducted via water banking or a so-called spot market. These trades are generally short-term or one-time sales. One type of water banking that is becoming more common is the dry-year option. In such a water sale, the buyer who anticipates future water shortages can purchase the "option" to draw a certain amount of water from the seller at a future time. Other water transactions by "water trusts" also occur when an action group or board purchases water for environmental uses to restore stream flow or water levels in wetlands. Recently, there have been some long-term sales that stretch over decades. These are usually controversial because of their more "permanent" redistribution of water resources. By far, the most common kind of water trading that occurs in the American west, and certainly involving the Colorado River, is done through a water bank.

In order to operate a water market or bank, excess water is created in a variety of ways. One of the most common methods today is through land fallowing. Farmers agree to leave fallow some fields and sell the water they would normally use to irrigate those fields to other users, usually urban water districts. There are many challenges to such water trades. One is the difficulty measuring the amounts of water a farmer actually uses and thus has available to sell, excluding any return flow that re-enters the river or aquifer. The water

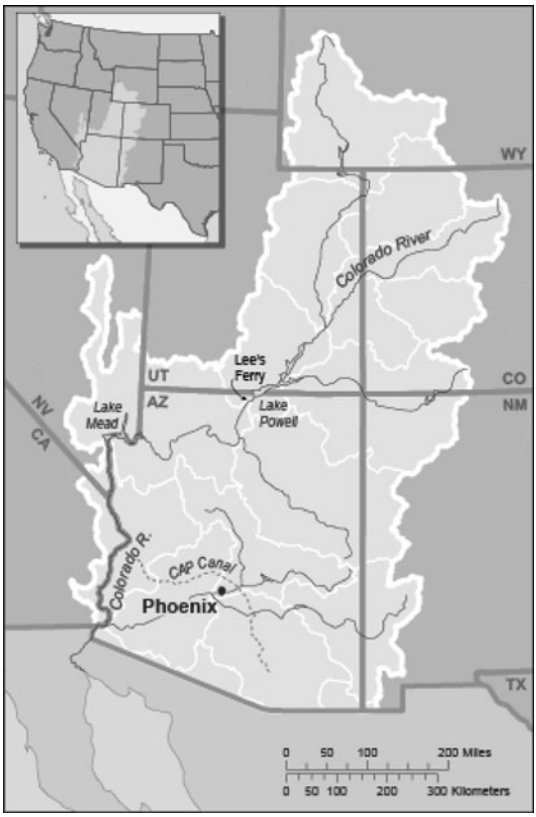

Fig. 1 Map of Colorado River watershed, http://watersim.asu.edu/watersimbackground.aspx

exclusive of return flow is called consumptive use and remains very difficult to quantify. Another way to create excess water is through recycling wastewater. Such water is normally easy to transfer or "wheel" to irrigators or industries, but less easy to sell to urban users. Often, pumping groundwater substitutes for surface waters or a certain user with rights to surface water agrees to pump ground water and sells the surface water. This transfer, of course, does have the negative impact of possibly over-drawing groundwater resources. In fact, many water users engage in conjunctive use, the combination of surface and groundwater.

Another common transfer method in the American west during the past decade or more comes through water storage. A user will store unused water in underground aquifers during wet years and pump this water out during shortfalls. Sometimes this kind of water banking or transfer takes place when an entity like the Los Angeles Metropolitan Water District (MWD) pays someone else to store water in their underground aquifer, with the city paying wheeling and storage costs as well as pumping and delivery costs later when the stored water is needed. Other ways to find excess water for transfers consist of water conservation initiatives, sometimes subsidized by the prospective water buyer. A metropolitan area might pay for water-saving irrigation and pumping infrastructure with an agreement that any water saved would be sold back to the city. In this scenario, water that was otherwise wasted is used in a city without the need to reduce agriculture and any unintended income loss for that region.

Development of an American water market

The case of water markets in the American west is an interesting study of reluctance to commoditize water and concern about how to prevent such marketing from damaging third parties to the transactions. Yet, a market has functioned there for the last two decades in some form or another. To understand the growth and challenges of marketing the Colorado River's water, the story must begin with California.[1] For the first half of the 20th century, water users in that state and the rest of the arid west relied on the Bureau of Reclamation—i.e. the federal government—to find and utilize new sources of water. When water shortages seemed imminent, a state or municipality requested federal help to build another dam or canal. Los Angeles's efforts to procure water from a distance first occurred at the turn of the 20th century when William Mulholland and his team bought up land and its water rights in the Owens Valley, 402 km (250 miles) away from Los Angeles. Piping all that water away from Mono Lake and the valley turned it into a dust-filled wasteland. This "water grab" became consistently linked with any later efforts the city made to obtain more water. In many ways, the Owens Valley experience is still a formidable obstacle for L.A. and other southern California urban areas.

Even though Los Angeles successfully procured water from that valley by 1913 and later added the all-important pipeline from the Colorado River between 1933 and 1941, Los Angeles was anything but secure in its water supplies. The 1922 Colorado River Compact had allocated only 4.4 million acre-feet (maf) per year (or approximately 5.4 billion cubic meters) to the state, but it was consistently using more than 5.2 maf or 6.4 billion cubic meters (bcm) while other states were not using all of their own allocations.[2] This condition was not a problem until the 1960s when California lost the Supreme Court Case *Arizona v California* in 1963 and Arizona managed to obtain long-sought funding for the Central Arizona Project pipeline, known as CAP. Two effects of this case are relevant to this discussion: the impending loss of excess Colorado River water California needed, and the legalization of federal water transfers written into the judgment. For the first time, Bureau of Reclamation water contracts could be traded to other thirsty buyers on a temporary basis.

As the Los Angeles area population continued to boom in the late 1960s and early 1970s, it struggled to find more water. The last major water project built in California was the State Water Project. A series of dams, reservoirs, pumping stations and canals, it is the largest state-built water project in the United States. Bringing water from the northern part of the state to the south, the California Aqueduct waters the San Joaquin valley with most

[1] Some of the best literature dealing with California water issues includes Norris Hundley Jr.'s, *The Great Thirst: Californians and Water—a History* (2001); and two classics on western water in general are Marc Reisner's *Cadillac Desert: The American West and its Disappearing Water* ([1986] 1993); and Donald Worster's groundbreaking work *Rivers of Empire: Water, Aridity, and the Growth of the American West* (1985). One of the most complete examinations dedicated exclusively to the Colorado River is Philip L Fradkin's *A River No More: The Colorado River and the West* ([1968], 1993).

[2] An acre-foot is the amount of water it takes to cover one acre of land one foot deep, or approximately 325,851 gallons. This is the primary unit of measure used for water flow in rivers in the United States. It is roughly equivalent to 1,233 m^3 or 1.2 million liters. 1 million acre feet per year (maf) equals approximately 1.2 billion cubic meters per year (bcm). The complete annual flow of the Colorado River over the last fifty years averages around 15 maf or 18.5 bcm (although recent droughts have reduced annual flows in some years to as low as 9.2 maf or 11.4 bcm) between 2002–2004. The 1922 Colorado Compact allocated a total of 16.5 maf or 20.4 bcm per year. This allocation plan creates an average over-draft of approximately 1.5 maf or 1.9 bcm each year. For more information on average yearly flows, see US Department of the Interior, US Geological Survey website, http://pubs.usgs.gov/fs/2004/3062/ (accessed October 8, 2010).

of the water going to support agriculture. Los Angeles still needed water, but times had changed in the 1970s with the arrival of the environmentalist movement. Any proposals for new dams or canals received much scrutiny and opposition and with the passage of the Environmental Protection Act in 1970, the dam and large project-building days were mostly over.

In addition to the challenges of the environmentalist movement in the 1970s, the west experienced a severe drought between 1976 and 1977. During this drought crisis, the Bureau of Reclamation stepped into provide emergency water in California through a temporary water bank. This experience paved the way for future water markets, especially in times of crisis. Because the water bank worked reasonably well, some argued it was and should be the wave of the future in the story of western water. Several reports advocated the development of water transfers to address shortages in California, but many remained skeptical that an operating water market could be successful (Phelps et al. 1978). Still, in 1980, California passed a law that made trades easier by declaring that water transfers of any kind were not an abandonment of a right. In other words, just because someone with water rights was not personally using that water did not mean they lost the right under appropriative water law (Newcom and McCarthy 2000).

Growing out of ad hoc rules miners used to keep the peace in the gold rush days of the American west, the doctrine of Prior Appropriation meant that whoever arrived first and mined the gold, or land, or water, had priority rights to it. These miners' codes eventually became legal statutes. As this law evolved, whoever had physical control of water had the right to divert it to any "beneficial use." This stipulation was meant to ensure that individuals or companies did not hoard water, a scarce resource in the arid west. One could not simply "own" the water and keep others from using it. Beneficial use dictated that whoever diverted the water or claimed it had to actually use it for some tangible and beneficial purpose.

By 1982, it was clear in California that some kind of water transfers through a type of market would be one of the few options for cities like Los Angeles and San Diego for future water resources. While the population continued to expand exponentially, Arizona was completing major portions of the Central Arizona Canal and would soon be taking its full share of water from the Colorado River. Plans to build a Peripheral Canal to bring northern California water around the delta region to south was defeated in 1982, a significant loss in L.A.'s hunt for more water. Clearly, the only way to obtain more water would be through conservation and buying someone else's water.

As the debate over water markets heated up in the mid 1980s, another severe drought hit the arid west, particularly California, and lasted through 1993. In the midst of water shortages, discussions about water markets again moved past the theoretical. Partly a result of an El Nino in the Pacific during 1986 and 1987, the drought became one of the worst in American history by 1988, spreading that summer over 36% of the country. As the rest of states began to recover, however, California's drought dragged on, leading to shortages.

The most interesting water marketing during this drought took place in 1988. In southern California just north of the border with Mexico, vast agricultural enterprises and fields of crops cover what is known as Imperial Valley. The Imperial Irrigation District (IID) is its primary utility company and has some of the most senior rights to Colorado River water, wheeled to farmers through the All-American Canal. The 1988 agreement set up a 35-year water transfer from IID to Los Angeles by use of a water conservation program that included canal lining and reservoir regulation. L.A.'s MWD paid for the program in exchange for the water saved—approximately 100,000 acre-feet (123 million cubic meters) per year. Ten years later, IID would sign a similar agreement with the San

Diego County Water Authority (SDCWA) for almost double the amount over a ten-year period.

In both 1991 and 1992, California's Department of Water Resources set up emergency drought water banks. In both years, the majority of the water sold to the water bank came from fallowing agricultural land. The very first such agreement was the 1992 transfer from the Palo Verde Irrigation District (PVID) to MWD which fallowed approximately 20,000 acres (about 8 ha) for a period of 2 years. The prices were set to account for the cost of wheeling the water and cities happily paid the price for a secure water supply. Most analysts agreed that water banking seemed to work well, especially during the 1992 experiment (Howitt 1994). Yet in spite of the challenges, many predicted that future water shortages could not be met with temporary and intrastate trades alone (Booker and Young 1994). During the 1990s, analysts saw the impending completion of the Central Arizona Project, potentially taking Arizona's full 2.8 maf (3.5 bcm) out of the mainstream of the Colorado River.

Other developments in water marketing began to appear in the late 1990s. In 1996, Arizona created the Arizona Water Banking Authority and was soon working on water trade and storage agreements with Nevada. In the late 1990s, Las Vegas experienced exponential population growth and was desperately seeking more water resources. Arizona's CAP was only running at about 73% capacity in 1996, partly because of the high costs of the water. Farmers preferred pumping cheaper groundwater instead of paying for CAP water, so Arizona began storing some of its 2.8 maf (3.5 bcm) in underground aquifers through recharge. Arizona agreed to sell some of its water allocation to Nevada, who would take the purchased water out of Lake Mead. Arizona would take an equal amount of water out of the underground aquifer for use instead of from mainstream flow. In this way, an interstate market functioned, although some preferred to call it a water bank (Economist 1998).

The largest and still the most important water transfer agreement of Colorado River water had its origins around 1996. For most of the years since the *Arizona v California* decision in 1963, California drew more than its 4.4 maf (5.4 bcm) allocation from the river. With the exception of a few years in the early 1980s, California was using an average of 5.2 maf (6.4 bcm) per year. Until 1996, this excess came from water that Arizona and Nevada were entitled to, but not yet using. In that year, both started using their full allocations, which meant that California was drawing water considered "surplus." Five years later, the Department of the Interior initiated what were called "Interim Surplus Guidelines" that allowed California to draw a certain amount of extra water from Lake Mead, but with the understanding that it would begin reductions. California needed to demonstrate it was making reasonable progress in reducing its demands for Colorado River water and as long as it did so, the Dept. of the Interior was willing to gradually wean the state off the extra water (Bureau of Reclamation 2001).

Without major water transfers, however, California's use of Colorado River water continued to exceed the 4.4 maf (5.4 bcm) allocation and in early 2003, the Secretary of the Interior declared California in violation of the Interim Surplus Guidelines. This meant that California would not be allowed to draw surplus water from Lake Mead, but would have to make do with the 4.4 maf (5.4 bcm) immediately. This declaration sent shockwaves through state government and the leadership of the many water district organizations throughout the southern part of the state. Much of the overdraft of Colorado River water went to Los Angeles and San Diego whose populations had rapidly expanded. Leaders of the urban water districts had already begun talks in 2001 with some of the

agricultural water districts that had priority rights to Colorado River water. These talks had ended in stalemate, but were resumed with new urgency in 2003.

Finally in October, an agreement was struck that would, if implemented, mean the largest agriculture-to-urban water transfer in U.S. history. Consisting of 35 separate agreements, the major results would be a transfer of approximately 30 maf (37 bcm) of Colorado River water from the Imperial Valley and Coachella Valley irrigation districts to Los Angeles and San Diego over a period of 75 years. In effect, this meant a transfer of around 2.5 maf (a little over 3 bcm) per year from agriculture to urban water users. The major signers of the agreement were two government bodies (the U.S. Department of the Interior, the State of California), two agricultural water districts (Imperial Valley irrigation District, Coachella Valley Water District), and two urban water districts (San Diego County Water District and Metropolitan Water District). These two water-hungry cities agreed to pay for and receive water transfers and pay millions of dollars to address resulting environmental impacts, such as declining water levels and quality of the Salton Sea (SDCWA 2010a, b).

The major problem with the agreement was that it committed the state of California to an unknown amount of debt that would come from the Salton Sea restoration project and other water-saving projects like canal lining. While water districts like MWD would also pay large portions of these bills, state authorities questioned the legality of assuming such a large and unspecified amount of debt. Litigation ensued, although water transfers from fields to cities began right away. Almost 7 years passed before the California Superior Court ruled the Quantification Settlement Agreement invalid in February 2010. It is uncertain what will happen in the future with this agreement, but appeals have been filed and some expect the agreement to eventually become binding with some modifications.

Meanwhile, MWD and SDCWD continue to receive and pay for water transfers from Imperial and Coachella valleys. These water transfers were made particularly vital by the ongoing drought that reduced the Colorado River's flow. In 2005, California traded 1.2 maf (1.5 bcm) of water, about 3% of the state's annual water use (Hanak 2005). The Imperial Irrigation District water sells approximately 80,000 acre-feet (99 million cubic meters) of water each year from farms to San Diego. Parts of the canal-lining projects have been completed or are currently under construction (San Diego Co Water Auth (SDCWA) 2009). The water savings alone are expected to provide 100,000 acre-feet (123 million cubic meters) without any land fallowing. There is also a mitigation fund that can be tapped to meet other negative impacts, including environmental impact on wetlands (Hanak 2007). None of the parties, however, are paying attention to the impact canal lining will have on groundwater so important to farmers across the border in Mexico.

Benefits and costs

During its development over the past fifty years, many analysts have debated the costs and benefits of marketing water. By the mid 1980s, a significant body of scholarship already existed supporting reallocation of water through a market. The first and most beneficial result usually cited was a better division of water to the most efficient user. Economist B. Delworth Gardner argued in his 1986 book chapter "The Untried Market Approach to Water Allocation," that the Colorado River should especially be allocated via a water market that gave water to the "highest valued users (Gardner 1986)." The limited and

over-allocated resource of that river, Gardner asserted, was often used to grow low-profit crops on over-watered farmland instead of being used more efficiently.[3]

Some scholars argued that transfers of river water from the upper basin to the lower basin where it produced higher-value crops would be the most beneficial distribution of water. In Colorado, for example, the average elevation is 6,800 feet (2,073 m), making the average growing season around 150 days a year. The largest crops grown in Colorado and the other upper basin states of Nevada and Wyoming are mostly alfalfa and feed grains. In contrast, large areas of California and Arizona have nearly year-round growing seasons, yielding much higher-value crops for a similar amount of water. Another effect of an interstate water market would include more water in the lower basin for hydroelectric generation and mitigation of high salinity levels. Although the Upper Basin states would be forced to take on some costs of such transfers, some economics argued that the Upper Basin should share more in the negative effects of heavy Colorado River water use. An interstate market redistributes both benefits and costs in a more equitable way (Booker and Young 1994).

From many perspectives, the most important benefit to water marketing is a more realistic price that would better reflect the actual value of water and encourage conservation. Some municipalities such as Tucson, Arizona have experimented with raising the price of water to help motivate people to conserve. Such plans face considerable resistance from urban water users, but might work better in agriculture by distributing costs and thus encouraging conservation. Redistributing water to higher value uses would also give more to industry. For example, a common comparison is made between cotton and microchips. For one acre-foot of water (1,233 m^3), the value of irrigated cotton or alfalfa is approximately \$60 and 3 full-time jobs, while the same amount of water can produce \$1 million worth of microchips and 9,000 jobs (Glennon 2005). More generally stated, one acre-foot (1,233 m^3) of water can yield approximately \$350 in profits from farm produce. Conversely, the same amount of water could produce \$300,000 in income from industrial products (Baronskey and Abbot 1997). From these perspectives, a water market would reallocate resources to the highest valued uses.

Another way to think about market reallocations is the impact on ownership. Some economists suggest that individuals should hold all water rights instead of water districts or states. If an individual obtained their water through a market purchase or sold excess water to the highest bidder, he or she would be more likely to conserve and efficiently use water (Gardner 1986). Sellers of water rights will benefit from the increased value and buyers will be motivated to both conserve and apply water to the highest possible economic benefit (Glennon 2005). In this way, a water market impacts water law by placing ownership into users hands. Such a system would require the removal of all barriers to interstate trades of water.

Today, the primary beneficiaries of water marketing are urban areas. As metropolitan areas like Los Angeles, Phoenix, and Las Vegas increase exponentially in population, cities look for new resources. Since cyclical drought and other pressures have caused the over-allocation of the Colorado River and groundwater aquifers, cities cannot simply build a new canal or reservoir. The only place to find new water is from purchases, usually from agriculture. In this way, the water market redistributes resources away from agriculture to urban and industrial uses, and from one region of lower population to more dense areas. Consequently, states move water from one to another to correspond to changing market demand.

[3] For earlier works advocating water markets, see Gardner and Fullerton (1968); Hartman and Don Seastone (1970); Meyers and Posner (1971); Anderson (1983); and Vaux and Howitt (1984).

Many analysts argue that water marketing can also provide a substantial benefit to the environment. One example is pollution. While government bureaucracies seek pollution mitigation with uniform laws and regulations, a market place allows for a more nuanced approach to a problem that is anything but uniform. Controlling some points of pollution are easier than others, so some economists advocate using the buying and selling of pollution credits. If a watershed is treated as a single unit, some kind of uniform total standard for pollution can be established. Within the watershed, some users who find it very expensive to mitigate pollution like salinity can buy credits from other users for whom it is much cheaper to control contamination. Those who can better afford costs are thus encouraged to mitigate even more pollution in order to build up tradable credits (Anderson and Snyder 1997).

Other potential environmental benefits include the ability to purchase water for in-stream flows. Some theorists assert that individuals should be able to purchase water in order to preserve stream flow if they so desire. Howe (1997) suggested that the old "beneficial use" principle attached to appropriative water rights in the west be discarded. People should be able to purchase a long-term water right in a market that the person might not use for a very long time. Hotels and restaurants that might be affected by a reduced stream flow should be allowed to purchase water rights to maintain that flow. Others argue that since many regions benefit specifically from recreation and tourism, an open water market would actually help preserve in-stream flows. Economic development then will be automatically regulated by the economic interest in environmental preservation (Clayton 2009).

Another region experiencing some benefit from water marketing is the Colorado River Delta in Mexico. Bureau of Reclamation dams and reservoirs that make urban areas like Las Vegas and Los Angeles possible, deprive the delta wetlands of water, further stressing already endangered species. American efforts in the early 1970s to reduce salinity levels from agricultural runoff led to the construction of a bypass canal that took salty water south of the Mexican border into the Cienega de Santa Clara wetlands. When drought and lowering reservoirs led to further water conservation and the restarting of a long dormant desalting plant in Yuma, flow to the wetlands decreased and may continue decreasing upon completion of a new reservoir under construction on the California-Mexican border. As part of a solution to reduced water flow, several university and non-profit groups formed the Colorado River Delta Water Trust in 2005. This trust is currently purchasing water from agriculture in order to restore regular flows as well as periodic flooding necessary to mimic natural conditions in the delta.

While there are a number of clear benefits of a water market, there are also many problems that dampen the enthusiasm of some experts. In 2001, scholar Kenneth Frederick asserted very eloquently the ongoing barriers to a water market. "The Fugitive nature of the resource," he argued, "the variety of services it provides, and interdependence among users limit the potential for efficient water marketing (Frederick 2001)." He also acknowledged that third-party impacts from water transfers would have to be addressed, but that it would be a difficult task since such impacts would be very difficult to measure. Probably the most significant barrier is the impact a water market often has on farming communities. If water is leased or sold from one state to another, farm workers lose jobs.

Third party impacts in farming communities go far beyond the simple loss of agricultural labor employment. Farming communities develop around the farmer and many different kinds of businesses would feel the impact; farm equipment dealers, seed and fertilizer sellers and bankers. Community restaurants, retailers, even schools suffer from declining property values and taxes. Area lakes could lose important water needed for

recreational activities and tourist dollars. Rural water users also continue to see the specter of Mono Lake in the dry Owens Valley and fear that agricultural transfers to urban users will eventually empower entities like the Metropolitan Water District to take more water, effectually killing local economies. While urban users are willing to pay higher prices for water and such cost increases might encourage water efficiency, rural politics sees such agricultural-to-urban water transfers as a threat.

Perhaps not often considered by American economists is the fact that Mexican farmers also experience third party impacts. Spurred partly by serious drought in 2004, state and federal government looked for ways to conserve water through canal-lining projects and desalination. However, seepage from the unlined canals recharged groundwater in Mexico, helping both farmers and the delta wetlands further south (Megdal 2004). In 2009, the Bureau of Reclamation lined 23 miles (37 km) of the All-American canal with concrete to prevent seepage and by early 2010, 35 miles (56 km) of California's Coachella Canal was also complete (San Diego County Water Authority 2010a, b). A significant source of groundwater recharge along the border was thus lost, causing international strains.

A similar conservation project, the so-called "drop 2" reservoir authorized in 2005, will catch excess water at the border. In the past, farmers might order a water delivery from upstream in Lake Mead which takes 2 or 3 days to reach its destination. If rain came before delivery, the farmer might cancel the order in order to save money. Previously, this water would flow across the border to Mexican farmers. The state of Nevada funded construction of the new reservoir in order to buy water for Las Vegas. The city will pay Arizona or California for water from Lake Mead and the state further south would draw water from the new reservoir if needed. This plan will work well for conservation and water marketing inside the US but will create significant negative impacts on Mexican farmers and delta wetlands (Gelt 2008).

Another important third party impact or externality is the effect of marketing on groundwater. Economist Mason Gaffney identified what he saw as "unconstrained pumping." As long as farmers could pump unlimited amounts of groundwater, prices for surface water would remain low, interfering with water marketing (Gaffney 1997). If water that is not used by a person or group of people is sold and transferred away from its current stream or aquifer, local water users may resort to over-pumping groundwater, leading to subsidence, increased salinity, and the lowering of the water table. Often, a water user who trades surface water on the market replaces that water by pumping groundwater, creating other third party impacts in the region (Glennon 2005). Known as conjunctive use, many water sales today combine surface trades with groundwater to replace traded water.

Some economists argue that until the costs for transfers are addressed and shared between buyers and sellers, these costs will discourage participants in a water market. One study illustrated that while transaction costs that came from administering a market were usually shared equally (establishing prices, negotiating delivery schedules and wheeling methods), policy-induced costs such as compliance with state laws and mitigating third-party impacts were almost exclusively born by the seller (Archibald and Renwick 1998). The answer to some of these problems might be addressed by including the costs of such impacts in the price of the transactions (Haddad 2000). The only way to actually monitor and control third party impacts or externalities, some argue, is through government regulation of the water market. Thus, a completely "free" market governed solely by the laws of supply and demand is not practical. How to create a working balance between open marketing and government regulation, however, is still a considerable challenge (Hadjigeorgalis 2008).

While some economists have argued persuasively for water markets, others simultaneously argue that water should not be commoditized. Published in the same volume as Gardner's advocacy of water markets in 1986, scholars Helen M. Ingram, Lawrence A. Scaff, and Leslie Silko countered with a discussion of the dangers of water marketing. Because of the third party impacts of a water market, the authors argued that water is a "social good," not owned by any individual. According to this Public Trust Doctrine, the government should act as a trustee for water supplies and allocate water according to an "equity doctrine (Ingram et al. (1986)." The major principles of this doctrine would be reciprocity and good-faith obligations for all water users.

More scholars are paying attention to issues of equity and water. Sustainability is perhaps the most recognized term in environmental conversations today, but a close second might be Environmental Justice. If humans have a basic human right to water, then some see growing commoditization very troubling. Most water sales do come from smaller farmers to either municipal entities or larger agribusiness and this condition does transfer control of an important commodity to a smaller elite. Yet some scholars argue that such a market actually improves equity issues by giving small farmers access to revenue they would not have otherwise (Hadjigeorgalis 2008).

Current challenges and possible solutions

The major barrier to water marketing today was clearly identified by a California's Legislative Office report in 1999.[4] In that report, the authors argued that the most difficult part of marketing water in the state was the unclear and over-lapping laws regulating water transfers. Some transfers needed federal review if it involved water from a federal system, like the State Water Project. Others required only state oversight and still others only needed agreement between local water districts. To address this problem, the Legislative Analyst's Office urged the passage of a single water transfer act that would cover all the important circumstances in a coordinated way (LAO 1999). It also suggested that water rights in the state be better quantified, that information on all water transfers be published in a central location so that everyone could see and better participate in the process, and that the law address third party impacts in a fair way.

Part of the reason the authors of the report considered new legislation important was the forecast for severe water shortages in the future. According to statics cited in the report, California was using approximately 79.5 maf (more than 98 trillion cubic meters) per year. Environmental uses accounted for the largest portion at 46%, agriculture used 43%, and urban areas only 11%. This 79.5 MAF was met in the following ways: 20% from various federal projects, 8% from state projects, 13% from the Colorado River, only 1% from recycling and desalination, 27% from local surface projects, and a full 31% from groundwater. Unless the state found ways to increase recycled water and redistribute surface waters, shortages of 2.4 maf (3 bcm) would occur in good years by 2020 with a staggering shortfall of as much as 6.2 maf (7.6 bcm) in times of drought. If all states in the Colorado River basin did a similar analysis, the predicted shortfalls would likely be equally worrying.

[4] More than three decades earlier, the federal government commissioned a national water survey. The commission report completed in 1973 clearly outlined the over-lapping layers of policy and control extending from federal policy and legislation to state regulations to community politics and governance (Nat Water Comm 1973).

While many see the need for a redrawing of laws to allow for a free water market, not everyone agrees on how that market should operate and who can participate. Privatization of water is one of the proposed ways to encourage more long-term water transfers through a fair market. A proposed 50-year agreement between the Cadiz Water Project and the MWD was one such transfer. Founded in 1983, Cadiz, Inc. is a land and water resource company that discovered a large aquifer under its land holdings in the Cadiz valley of eastern San Bernardino County. Excess Colorado River water from the aqueduct would be stored in an underground aquifer owned by Cadiz. For storage and wheeling costs, Los Angeles could tap these stored waters in times of drought. Delays and a long, 5 year environmental impact analysis, however, cooled MWD's interest in the project and they withdrew from the agreement in 2003. The company continued to pursue its plans without MWD and in June of 2009, signed water delivery agreements with five other southern California water distributors. The large aquifer and plans to replenish pumped water through stored recharge is expected to provide enough water for around 400,000 southern California residents per year.

There are several other private water companies that are participating in a growing water market in California. Azurix Corporation purchased land in Madera County, California in 1999 in order to create a large underground storage unit for water. Azurix was, however, a subsidiary of Enron Corporation and found its stocks falling apart in connection to Enron's own crisis. Azurix-North America was sold in 2001 to American Water Works. Western Water Company is another private entity that buys and sells water in California and the west in general. In 1998, it was the first private company to transfer a sale of water using public infrastructure. The company obtained rights to wheel the water through part of the State Water Project pipelines to Los Angeles. More of these kinds of sales are likely in the future. Western Water Company also developed water supplies from Cherry Creek in Denver, Colorado (Western Water Company 2010).

Still, privatization has its own challenges and drawbacks. If a company owns water for sale, there is minimal chance for any kind of public or governmental oversight. A company can sell to the highest payer or give reduced rates to someone with power or influence. Thus, privatization strengthens the chances for an unequal distribution of water in favor of an elite. Likewise, there is little incentive for private water companies to mitigate environmental externalities or to respond to public interests. Robert Glennon argues that no American governmental unit should hand over water ownership to a private company. While such actions might make sense in countries where the government has failed to deliver water, a US market needs continued governmental oversight and regulation to keep powerful private corporations from creating an unbreakable monopoly on water Although Glennon concedes that most water in the American west is already privatized (mostly owned by private agricultural interests), he believes that ongoing government oversight can help a water market operate efficiently (Glennon 2005).

In view of these challenges, most water marketing and transfers in the near future will continue to be conducted between public water districts. Since agricultural water districts have the largest water rights to the Colorado River, most marketing today consists of agricultural to urban transfers. Even though the largest such transfer, the 2003 Quantification Settlement Agreement is still under litigation and modification, the Imperial Irrigation district did receive confirmation that it could legally make such a large and long-term water transfer and has done so for the past seven years. As recently as April, IID president Brian J. Brady (2010) testified to Congress that the IID would continue the transfers. However, he also admitted that there were problems. "There can be no enduring settlement of longstanding disputes among Colorado River water users within California,"

he asserted, "without a credible resolution of the transfer mitigation question and impacts to the Salton Sea." Agreeing with many others that third party impacts had to be addressed, he argued that effects of transfers on the Imperial Valley also needed attention. "And the water transfer paradigm of the future is only viable if it works for the Imperial Valley today," he concluded. Many farmers and farm workers protested the transfers, fearing their land values would fall and jobs disappear while a few made money on cheap water. Still, others argued there was no other practical way the IID could ever have modernized their water delivery systems and certainly no other place L.A. or San Diego could find more water sources (Glennon 2009).

Although there are still remaining challenges to a water market in the west, the recent drought has encouraged such intrastate transfers, most of which have been legally formalized. Ongoing discussions about third-party costs, however, continued to create doubt about the long-term effectiveness of a market for western water, especially in California. Some argued that to mitigate these impacts, especially in agricultural regions that might lose jobs and other sources of income, costs could be exacted with transfer fees. Another way to address such impacts would be to schedule gradual transfers of water out of an area, allowing rural areas to find other economic revenue streams before all of it was transferred (Howe and Goemans 2003).

While most of the experiments in water marketing have been intrastate transactions, recent years have seen a growing interest and need for interstate transfers (California Water Report (CWR) 2005). In 2006, faced with ongoing drought, the seven states of the Colorado River basin created what is the first cooperative document since 1922 (and Arizona did not agree to that one until 1944). The Seven Basin State's Preliminary Proposal Regarding Colorado River Interim Operations (2006) was a response to Secretary of the Interior Gale A. Norton's plans to deal with drought when allocating Colorado River water between states. Demands have long exceeded allocations in southern California and Nevada. Along with many other recommendations, the proposal outlined an innovative method to encourage water conservation. To allow reallocations through water transfers, the states recommended a "credit system" they called "Intentionally Created Surplus (ICS)." Such "surplus" would be created through conservation measures that included land fallowing, canal lining, desalination, and other innovations to conserve water.

To use these credits, the states agreed to strict guidelines on how to measure conserved water and each state was given a limit on the number of credits it could use in a year. According to law professors Glennon and Pearce (2007) at the University of Arizona, this credit system was a radical departure. They made the following assertion:

> The ICS credit system is an extraordinary change in how Colorado River waters are used. Although it does not formally change the allocation of water from one state to another, it effectively operates that way. Nothing in the program prevents one state from buying water from a contractor in another state who has engaged in an activity that qualifies for ICS credits.

Nevada can draw more than its 300,000 acre-feet (370 million cubic meters) allowance from Lake Mead (and does) through this credit system, as do other states. Arizona currently receives credits for storing Colorado River water in its underground aquifers under the operation of the Arizona Water Bank Authority. In 2009, the Arizona Water Bank stored and delivered around 182,670 acre-feet (approximately 225 million cubic meters) of water, 40,000 (49 million cubic meters) of it was for the state of Nevada. In 2010, it expects to store approximately 152,600 acre-feet or 189 million cubic meters (Arizona Water Banking Authority 2009).

Although most of the discussion on water markets in the west center on California, the State of Colorado has been trading water for a long time. It has experienced heated water wars, especially between the western slope where most of the water is, and the front-range where most of the population lives. Recently, plans for more pipeline projects are being debated that would satisfy the water cravings of the front-range by taking all of the state's Colorado River allotment except for about 160,000 acre-feet (197 million cubic meters). One proposal is to build a 869 km (540 mile) pipeline from the Flaming Gorge reservoir to the Denver area. Another is for a 402 km (250 mile) pipeline from the Yampa River, one of the last free-flowing rivers in the region. There is huge pressure from local and environmental groups against both projects, essentially stalling them for the moment. The problem is that even if the controversial projects were constructed, they would only provide a mere fraction of the water Denver needs in the next 20 years (Colorado Bar Association 2009).

While Colorado and other states like Nevada contemplate building aqueducts and reservoirs, others are looking to technology for solutions. One of these innovations that might free up more Colorado River water for the market is "Source Metering." The development of a kind of meter to measure the amount of water a user diverts from a river, stream, canal, or reservoir, is a new instrument. First developed in 1993, source metering was established in Kansas, Texas, and Washington. These meters help users withdraw only the amount of water they need through precise measuring. Since according to some calculations approximately 36 states will suffer water shortages by 2013, source metering might be "an effective mechanism for responding to climate change (Lindsay 2009)." Another recent innovation is the measuring of evapotranspiration—a combination of water loss through evaporation and plant transpiration. Seeking to help farmers make better decisions about where and when to plant certain crops, the Idaho State Water Department developed metering that uses two orbiting satellites to send data back to analysts. The hope is that one day, individual farmers will be able to access this data with hand-held devices (Grimond 2009).

These new technologies, however, will not solve all western water problems. Although third party costs to water transfers need solutions, one of the most pressing issues is climate change. While Colorado River stream flows have varied quite a lot over the centuries, recent drought has created a significant conversation about the possible length of dry conditions in the west and why they might be much longer than a few years. In 2004, one report indicated that snowpacks, the primary source of Colorado River water (and indeed all western rivers), were declining. Since the 1950s, the global temperature has risen approximately .8°C since the 1950s. This seemingly small increase has created a "significant" decrease in snowpack in the American west. If even the most moderate predictions for global warming come true during the next several decades, snowpack in the west might be reduced by 60%. If this happens, stream flows in the region could decline by as much as 50%. With snowpack melting earlier in the spring, as well as decreasing in volume, water shortages in the summer will impact everything from agriculture to forests to fish runs (Service 2004).

Some scientists argue that not only will global warming turn more snowpack into rain, but that much more evaporation of rainfall will occur (Friederici 2008). Additionally, more rain instead of snowpack means more runoff and water loss through flooding. As both flooding and evaporation reduces water flowing into rivers, already over-drawn reservoirs may sink to new lows. The Scripps Institute of Oceanography predicts that by 2021, Lake Mead could be virtually unusable (Scripps 2008). If such dire predictions come true, then no amount of water marketing can fix the problem, but some argue that a free market for water today will conserve enough to stave off possible disaster.

Basin-wide planning and the future

Because of growing water demands in the southwest and the potential impact of climate change, river users in the upper basin are also talking about a larger project: an interstate water bank for the upper basin, called by some a Compact Water Bank. The fear is that one day, the lower basin will issue a "compact call," or demand that the upper basin meet its obligation under the 1922 Colorado River Compact to deliver a minimum of 7.5 maf (9.3 bcm) below Lees Ferry. Part of the reason the amounts have been met in recent years is because of water storage in Lakes Mead and Powell. When the latest severe drought hit in 2002, all basin states watched in fear as Lake Powell water levels declined by two-thirds by the end of 2005. In 4 years, the basin that had taken 17 years to fill (approximately 24.3 maf or almost 30 trillion cubic meters) had lost somewhere near 16 maf (19.7 trillion cm) (San Diego Co Water Auth (SDCWA) 2009).

In the face of this major decline in supply, people in Colorado began to worry, especially Denver and other front-range cities. There are basically two kinds of water rights that people in the state talk about today: pre-1922 and post-1922 water rights. Those who had water rights allocated prior to the signing of the Compact in 1922 are considered senior under prior appropriation water doctrine. Denver and many other cities in Colorado have water rights much more junior than much of the agricultural western slope. Colorado fears that a "call" on the river from the lower basin will mean a "compact curtailment." Under such a curtailment, those with senior water rights would receive their water first, leaving Denver and many other urban areas dry. One possible solution is a water bank for emergencies like a compact curtailment and has been under discussion in various forms since 2005. Post-1922 water right holders in Colorado might purchase the more senior water rights and bank them against a future compact curtailment (Iseman 2010).

The conversations, however, are still ongoing and it is not clear if such a water bank will be established. Some argue that the water bank would only postpone a water crisis, while still costing post-1922 rights holders for a useless plan. Others argue that the lower basin would never issue a compact call because of the threat of litigation. Some say that if water levels in the Colorado River drop drastically, all basin states will have to join together and remake the compact, redistributing a much smaller amount of water and spreading the cutbacks fairly. So far, no such discussions have occurred, in spite of the encouraging 2006 seven-basin state agreement on interim operations. Still, that recent agreement might have set a necessary precedent for future negotiations.

Regardless of the challenges and controversies, the western water market is here to stay and the Colorado River will remain a vital part of it. It seems clear that a water market must be regulated by government in some way to ensure that everyone has access to it, some kind of middle ground between free markets and public trusts. Perhaps the best designs for this regulation will come from basin-wide planning where governors and water districts cooperate with the Department of the Interior. Water analyst Delworth Gardner believed that "Water markets can be our salvation" (Gardner 1986). Yet, as many regions globally begin using water markets to meet demands, many important questions remain unanswered. What are the long-term impacts of water marketing? How can negative impacts of water marketing be addressed in order to preserve everyone's rights to water? Do we assert the validity of the Public Trust Doctrine, or do we find no other realistic answer than to commoditize water in a free market?

As economists, hydrologists, politicians, and historians ponder these questions, the developing water market in the American west can serve as a microcosm for larger global questions. Do we seek a marketplace for water where there will be winners and losers? Do we want equality where all users will be treated the same, but managed through government

mandates? These questions beg answers as the entire power structure of water continues to change. At least in the case of the Colorado River, control of water seems to be less of an imperial power than it once was. Some of the formerly powerful cities and water districts are paying more and controlling less. Even state governments find themselves challenged by the growing power of Native American communities with the most senior water rights in the west. Private corporations are taking larger pieces of the water market while agriculture slowly sells off some of its jealously protected rights. Water in the west still flows toward money. Having that water still equals power. The Colorado River is still serving humans who control it and divide its waters like a giant plumbing system. Yet, the river still shapes its users—by reminding us of our dependency on nature. While we funnel it, drain it, and deplete it, the river controls us in the end. Only time will tell if those of us in the arid west can remain there—how we interact with its river will determine the outcome.

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