Can Markets Improve Water Allocation in Rural America?

By Jason Henderson and Maria Akers

Water, one of the most fundamental resources for economic activity, covers about three-fourths of the earth's surface—but only 2.5 percent of that amount is considered fresh water. While freshwater supplies in the United States are relatively abundant, increasing demand and drought, especially in the Great Plains, have left some states wondering whether there is enough fresh water to go around.

The drive for greater efficiency in the use of water has led to the emergence of water markets. These markets allow for the equitable transfer of water rights from lower-value agricultural uses to higher-value uses, such as for emerging industries and growing municipalities. Many rural communities, though, view water markets as a threat to their economic foundation and future growth.

This article explores how water markets affect both water right holders and their rural communities. The first section describes how drought and water demand are straining existing water resources. The second section details how the emerging water markets transfer rights for water from rural to urban use. The third section examines the economic effects of water markets on rural communities. The article con-

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cludes that other mechanisms, in combination with water markets, may be needed to improve the efficiency of water allocation and compensate rural communities for lost economic activity.

I. WATER USE IN THE TENTH DISTRICT

Water has always been the life blood of the Tenth District economy.[1] Early pioneers of the Great Plains diverted water for crop irrigation, and since then, agriculture has been the largest user of water in the region. As the Midwest economy became industrialized after World War II, industries also became large water users. Today, these users are joined by rising urban populations, resulting in an unprecedented demand for water.

Growing demands for water have joined forces with nature to severely strain existing water resources. Over the past few years, persistent and severe drought has reduced stream flows, slashed water levels in district reservoirs, and depleted underground aquifers. In 2004, at the peak of the drought, many reservoirs in Wyoming were only half full, with some shrinking below 10 percent of capacity (Natural Resources Conservation Service). Even after increased precipitation this year, many reservoirs remain below historical levels.

Underground supplies of water have also declined. The High Plains aquifer, which underlies about 174,000 square miles of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, has lost about 6 percent of its stored water (USGS). This loss would be enough water to cover 200 million acres of land a foot deep. In places like western Nebraska, where current supplies are fully or over-allocated, concerns over water are intense, especially since current use already meets, or even exceeds, projected long-term supplies (Map 1).

The list of demands on existing supplies is getting longer. In 2000, agriculture accounted for 85 percent of the water withdrawn for consumptive use. Over the past half-century, dependable electricity and modern irrigation techniques, such as center pivot irrigation, have allowed farmers to tap groundwater sources, transforming semi-arid land into productive farmland (Comis; Groundwater Foundation).[2] By 1981, the number of irrigated acres in the Tenth District surged to over 13 million (Chart 1). By 2000, district irrigators were drawing 37 million acre-feet of water per year, nearly twice withdrawals in 1950.[3]

Map 1

FULLY APPROPRIATED AND OVERAPPROPRIATED GROUND WATER AREAS IN NEBRASKA

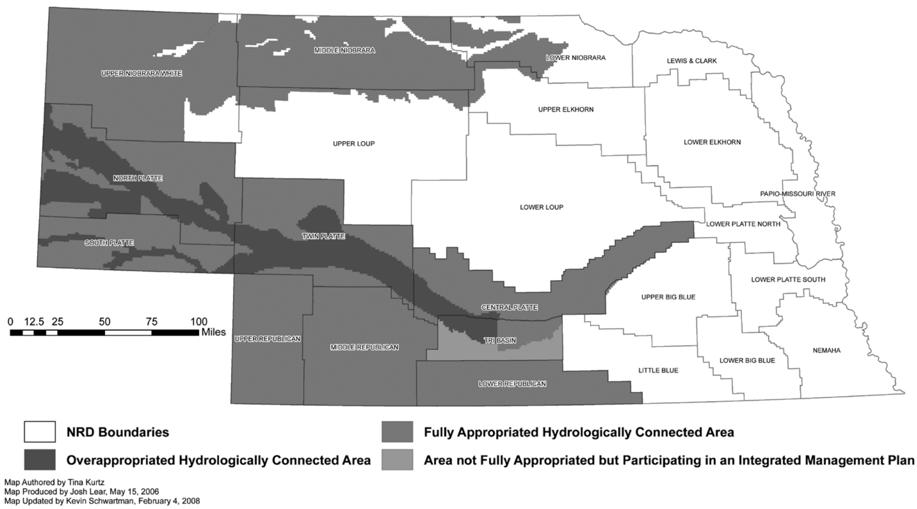
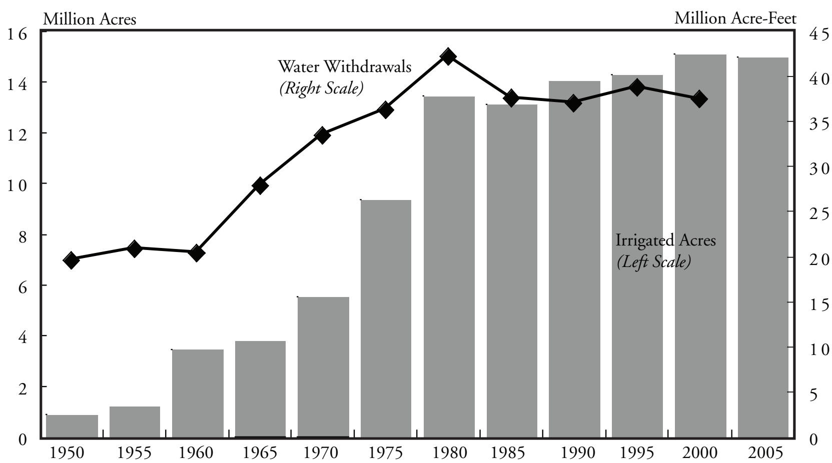


Chart 1:

TENTH DISTRICT IRRIGATED ACRES AND WATER WITHDRAWALS FOR IRRIGATION



Source: U.S. Geological Service and U.S. Department of Agriculture

Similarly, withdrawals by industrial users rose sharply following World War II. Rapid industrialization across the nation boosted manufacturing activity, peaking in the early 1980s. Industrial water use has tended to be even higher in places like the Tenth District, where manufacturing is concentrated in traditional water-intensive industries, such as food, pulp and paper, chemicals, petroleum and coal, and primary metals industries (Hutson and others; White).

Ethanol is a prime example of how industrial activity can boost water demand. Despite recent efficiency gains in using water, ethanol production remains a water-intensive process.[4] In Nebraska, anecdotal reports indicate that some ethanol plants have resorted to purchasing and then idling irrigated acres to acquire the water they need to operate.

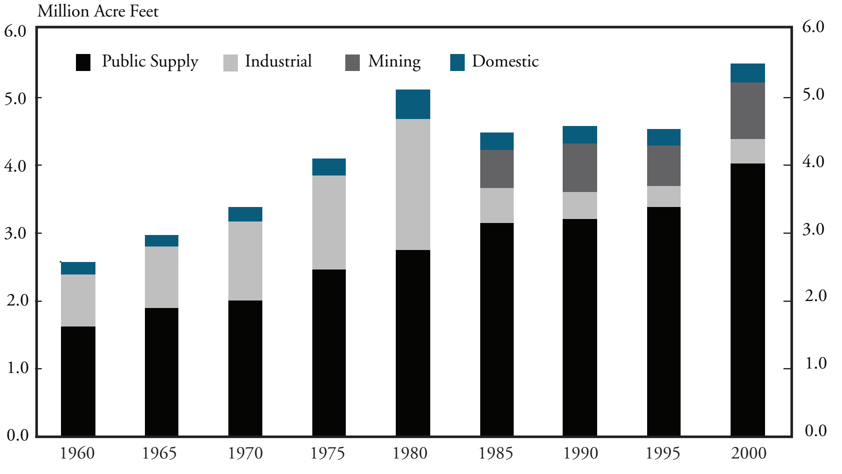
Recently, increased conservation efforts have checked both agricultural and industrial use. The rise in water withdrawals for agriculture has slowed since the 1980s, thanks to advances in irrigation technologies, increased conservation, and the stricter water quality standards imposed in the 1970s (Hutson and others). Still, over the past two decades, water demand has continued to rise, due largely to growing populations and rising incomes.

Growing populations have increased the demand for power generation, which uses water as a coolant or to power turbines. From 1990 to 2000, water use as a coolant in thermoelectric power generation climbed 19 percent in district states, with the largest increases in Kansas and Nebraska. Hydroelectric use, where water is used to power turbines, has increased water demand in the district's mountain states.[5]

Rising incomes, meanwhile, have increased the amount of water used for recreation, which in turn has boosted support for environmental preservation. The U.S. Fish and Wildlife Service reports that wildlife recreation participants—anglers, hunters, and wildlife watchers—jumped 13.6 percent from 1996 to 2006, spurring tourism and creating additional demand for water along lakes, reservoirs, rivers, and streams throughout the district.[6] At the same time, preserving endangered species and their habitat has spurred demand for water in natural stream flows. For example, the USGS is currently examining the impact of water use on the ecosystem of the Platte River area, which runs from southeastern Wyoming through northern Colorado and into Nebraska.[7]

Chart 2

DISTRICT WATER WITHDRAWALS FOR NON-AGRICULTURAL USE



Source: US Geological Service
Note: Prior to 1985, industrial use included mining use.

But the biggest surge in water demand stems from rising household and commercial use in urban areas. Over the past two decades, water for public services has boosted district water use 28 percent (Chart 2). The largest gains in the district occurred in metro areas, where population gains have been strongest.[8] In metro counties, public service water use rose 40.0 percent, compared to just 11.0 percent in nonmetro counties (USGS).

Expectations of rising populations are placing further pressure on the district's scarce water resources. From 2000 to 2030, district population levels are expected to rise 17.2 percent (Table 1). And, assuming no efficiency gains, public service water use should rise at a similar rate. The largest gains are expected in Colorado, at 35 percent. Improving the efficiency of water use could help alleviate some of the strain in the district, but even if public service use is capped at 2000 levels, per capita use would need to decline 15 percent to accommodate the expected growth. Colorado would have to cut its per capita use 25 percent.

Table 1
PROJECTED PUBLIC SERVICE WATER USE IN 2030

	Population (millions)		Percent of Population with Public Service	Total Public Service Use (Million gallons)		Per capita Public Service Use	
	2000	2030	2000	2000	2030 (Assuming 2000 per capita use)	2000	2030 (Assuming 2000 Total Use)
United States	281.4	363.6	0.86	43,300	48,104	178.9	138.5
District	20.1	23.5	0.85	3,595	3,583	210.8	179.8
Colorado	4.3	5.8	0.87	899	1,053	240.2	178.4
Kansas	2.7	2.9	0.93	416	423	166.4	152.1
Missouri	5.6	6.4	0.85	872	852	183.4	159.5
Nebraska	1.7	1.8	0.81	330	284	238.1	223.8
New Mexico	1.8	2.1	0.80	296	273	203.4	176.2
Oklahoma	3.5	3.9	0.91	675	697	215.0	189.6
Wyoming	0.5	0.5	0.82	107	93	264.3	249.5

Calculations based on Census Bureau and U.S. Geological Service data

II. EMERGING WATER MARKETS

The increased scarcity of water due to drought and increased use has raised tensions in reallocating water rights. For example, in the Platte River Basin in Nebraska, debate has emerged over reducing agricultural water use in order to support the habitat of endangered fowl and fish species (Platte River Recovery). The potential loss of access to water sources has pitted recreational users against agricultural users in the Niobrara River area in northern Nebraska (Duggan). Over the past decade, Kansas and Nebraska have battled over compliance with the water allocations in the Republican River Basin (Aiken). Existing water laws placed water rights primarily into the hands of agriculture. As new demands emerge, the desire for more efficient water allocation systems has intensified in the Tenth District, leading to the development of water markets.

On a national basis, water allocation is governed by state water compacts, agreements between states to coordinate long-term water management strategies. Water compacts are federal law because they are ratified by the U.S. Congress and are typically designed to limit the amount of water an upstream state can use, thereby guaranteeing downstream states a certain amount of water.[9] Most compacts divide water supplies on a percentage basis. For example, the Republican River Compact, ratified in 1942, allocated 49 percent of the Republican River's average annual water supply to Nebraska, 40 percent to Kansas, and 11 percent to Colorado, in proportion to the number of irrigated acres in the water basin in each state at that time.

Despite interstate compacts, disputes over water allocations have remained common, often requiring lawsuits to enforce compact terms. For example, in 1998 Kansas filed a lawsuit against Nebraska and Colorado before the U.S. Supreme Court to enforce the terms of the Republican River Compact. After the filing, the states involved agreed to a formal mediation process rather than costly litigation, and they arrived at a final settlement that was then approved by the Supreme Court. However, recent drought conditions have threatened the resolution, and Kansas is again challenging Nebraska over water use in the Republican River (Aiken). Over time, most of the states in the Tenth District have been involved in legal negotiations regarding compliance with interstate water compacts.

Inside state borders, water use rights in the Tenth District are governed by prior appropriation laws. The doctrine of prior appropriation, or "first in time, first in right," gives senior water rights to the first party that puts the water to a beneficial use. In this way, the senior appropriator establishes a priority date and acquires the right to divert water from an originating source, stream, river, or underground aquifer for a specific use at a particular location against later users or junior appropriators. Junior appropriators cannot use the water until the senior appropriator's claim is satisfied, and senior appropriators may not change any component of the original water right if it will affect a junior appropriator. Continued use of water is often necessary to retain priority status, and water rights may be lost by non-use.[10]

Under prior appropriation, water rights may not always result in the most valuable economic use. Today, agriculture still holds a large share of appropriated water rights due to the water use of early pioneers. As current water systems strain to meet rising demand, pressure mounts to reallocate water rights on the basis of improving the efficiency or the value of economic activity per unit of water. The pressure is particularly intense when the economic value of new types of water use is higher than traditional agricultural use.

Economists have long promoted the use of water markets as a mechanism to efficiently transfer water to its highest economic use (Howitt and Hansen; Gaffney). Markets bring producers and consumers together to agree upon the price and quantity of a good or service based on the cost of production and benefits of use. However, private markets were not historically considered to be the best mechanism by which to allocate environmental goods because of externalities—that is, the costs and benefits to stakeholders who do not participate in the market transaction. For example, diverting water from irrigated to municipal use could alter water flows that may affect environmental conditions. However, new insights into externalities have increased interest in the use of markets to enhance the efficiency of allocating environmental goods (Eigenraam and others).

One of the primary benefits of water markets is the ease in which water allocations can be altered. Under current laws, water allocations are fairly rigid, and changes in water use are often associated with costly and time-consuming negotiations and litigation. With markets, the transaction costs associated with water allocations are much lower. As long as sellers and buyers can meet and agree, they can arrange to permanently sell or temporarily lease water rights.

Water markets are also effective allocation mechanisms because they provide a flexible, transparent way to value water under varying supply and demand conditions. When water is scarce, the value or price will rise and vice versa when water is plentiful. For example, in the Colorado Big Thompson (CBT) water market, which allocates water from the Colorado River on the western slope of the Continental Divide to the eastern slope of the Rocky Mountains, water prices surged to over $13,000 per acre-foot in November 2002 as drought conditions intensified (Water Strategist). By 2007, increased precipitation prompted water prices to fall below $11,000 per acre-foot, before rising slightly in 2008 as drought conditions reappeared.

Given the rise in nonagricultural use, a common result of water markets is the transfer of water rights from agricultural to urban users. The U.S. Department of Agriculture (USDA) found that during the 1990s, water markets in the western United States often led to a transfer of water rights from rural to urban users (Gollehon). Over the past decade, the number of water transfers from agricultural to municipal use in western states has continued to rise steadily, while agricultural-to-agricultural transfers have declined (Brewer, Glennon, Ker, and Libecap). In 2006, 41 of the 50 sales in the CBT market involved irrigators selling water rights to municipal users. Market transactions from the CBT indicate that environmental purchases of water to restore wetlands and wildlife habitat are also increasing (Water Strategist).

The benefit of water markets is that the holders of water rights—typically agricultural producers—are compensated for their economic losses if they agree to transfer water to nonagricultural users. Assume that an agricultural producer considers selling or leasing his water rights. If the price of water is greater than the value earned from irrigation, the farmer could sell or lease his water right and convert his land to nonirrigated cropland. Or, if the price of water is less than the value earned from irrigation, the farmer could retain the water right and irrigate his cropland. As a result, the implementation of a water market could improve the economic position of the agricultural producer, as he could earn higher incomes through irrigation or a combination of nonirrigated production with the sale or lease of water rights.

While the transfer of water rights through markets compensates sellers for their loss of water, markets typically do not account for the externalities, or the third-party impacts, of reduced water supplies (Zilberman and Schoengold). For example, markets do not compensate society for the public value of water that may be affected. Individuals who own water rights may be willing to sell them for nonlocal use, despite the effects on the rural communities that rely on the water to support local economic activity. Water conflicts often arise from the difficulties of markets to value the third-party impacts that may result from such transfers.

III. WHAT IS THE VALUE OF WATER FOR RURAL COMMUNITIES?

While water markets offer the potential to improve the efficiency of water allocation and compensate water right holders for lost income, the lack of information regarding the overall economic impact of a proposed reallocation is often the primary hurdle in addressing water conflicts (Eigenraam and others). Research indicates that the transfer of water out of agriculture has led to economic losses for both agricultural interests and rural communities (Gollehon). Thus, water reallocation in the Great Plains is typically viewed as a threat to local economies. As with transfers in the Republican River Basin in Nebraska, the economic impacts can be large and often affect farm and farm-related industries.

The economic impacts of water losses can be separated into direct and spillover effects. The *direct effects* involve the water right holders themselves. In rural areas, water right holders are typically crop producers, who are compensated for their loss of income from their crops. The transfer of water and reduced irrigation lowers incomes by reducing crop yields and by shifting crop plantings toward crops that tend to generate lower revenues.

Spillover effects emerge as the lower farm incomes lead to less business activity and less household spending in the community. The switching from irrigated to nonirrigated production reduces nonfarm incomes, because nonirrigated crop production has smaller ripple effects on the rest of the economy. For example, farmers use less nitrogen fertilizer for nonirrigated corn production, which reduces sales by agricultural input firms (Selley and others). Smaller crops from nonirrigated production also reduce the transportation and storage needs for the crop, as well as the ability of the local farm sector to feed livestock and support additional processing activity. Thus, measuring the full economic impact of water transfers hinges on identifying impacts on the farm economy and on the links between farm and nonfarm activity in the region.

The value of irrigation (direct effects)

Several methods can identify the value of irrigation, or the direct effects on typical water right holders (Young).[11] Optimization models help analyze the impact of reducing water supplies on crop yields and crop planting mix. For example, a water optimization model developed by the University of Nebraska indicates that smaller water allocations lead to lower crop yields, fewer acres of irrigated corn plantings, increased plantings of wheat, and lower net returns.

Another way to approximate the value of irrigation is to compare cash rents for irrigated and nonirrigated cropland (Supalla, Buell, and McMullen). In an efficient land market, cash rents reflect the net returns farmers expect to receive from crop production. Because farmers incorporate both costs and revenue expectations in their planting decisions, the difference in irrigated and nonirrigated cash rents reflects the economic value of irrigation through both increasing yields and altering the crop mix. Higher cash rents for irrigated cropland reflect higher annual net returns (Chart 3).

The differences in irrigated and nonirrigated cash rents vary across location and over time. For example, in 2008 the difference between irrigated and nonirrigated cash rents in Colorado was roughly 33 percent higher than in Nebraska. Cash rents also vary within states. In Nebraska, the largest difference is in the drought-prone northwestern parts of the state, and the smallest difference is in the eastern part, where rainfall is more plentiful (Johnson 2007). The difference in cash rents also changes over time, as crop prices and irrigation costs change, thus shaping overall net returns.

Estimates of the value of irrigation based on cash rental rates are consistent with optimization models of crop planting decisions. Using Nebraska's water optimization model, the annual losses in net farm revenue associated with converting irrigated acres to nonirrigated production in the Republican and Central Platte river basins were estimated at $83 and $72 per acre, respectively (Supalla, Buell, and McMullen). In 2007, the difference between cash rental rates in southwestern and southern Nebraska ranged from $69 to $99 per acre, depending on the type of irrigation (Johnson 2008).

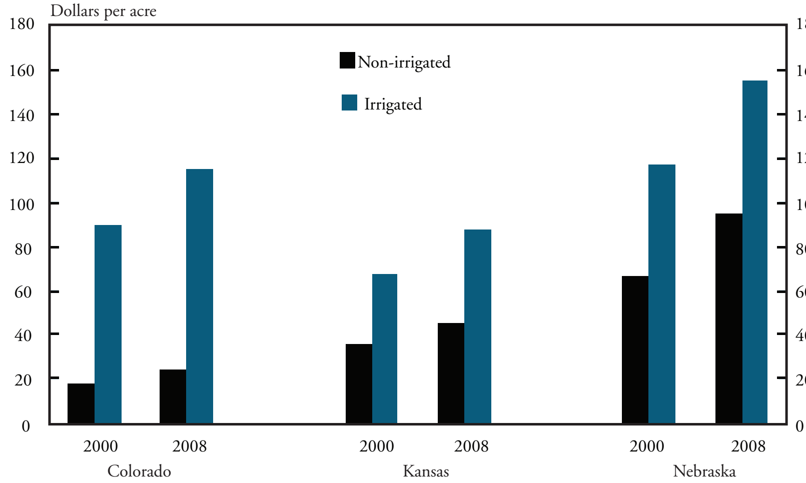
Business and household spending effects (spillover effects)

Input-output models can measure the economic links between industries and thus can help estimate the spillover, or third-party, effects of reduced farm income (Supalla and Nedved; Lamphear; Supalla, Buell, and McMullen; Thompson). These models estimate the indirect effects of fewer business transactions and less personal spending due to lower farm earnings. Input-output models derive multipliers from the industry interactions. The multipliers can then be used to estimate the value of economic activity lost due to a $1 loss in economic output.[12]

Economic multipliers are often location-specific and vary with the presence of agricultural service and manufacturing firms contained in the area. For example, economic multipliers for agriculture in Nebraska typically range from 2.1 to 2.4 (Lamhear). Other studies of Nebraska's Republican River Basin have identified an economic multiplier of 1.2

Chart 3

IRRIGATED AND NONIRRIGATED CROPLAND CASH RENTS IN COLORADO, KANSAS, AND NEBRASKA



Source: USDA, Agricultural Land Values and Cash Rents Annual Summary

(Thompson). In Colorado, similar variations emerge, as the statewide economic multiplier for agriculture has been estimated at 1.67 but ranges from 1.78 in the eastern part of the South Platte River Basin to 1.25 in the Republican River Basin (Thorvaldson and Pritchett). The off-farm impacts tend to be concentrated in farm input industries, depository institutions, and wholesale and transportation companies.

The current conflict between Kansas and Nebraska over water in the Republican River Basin shows the potential economic impact of water reductions. Kansas is currently challenging Nebraska's water withdrawals in the Republican River Basin (Aiken). To resolve the issue, Kansas proposed that Nebraska retire 515,000 acres from irrigated production. In contrast, the Nebraska Department of Natural Resources (DNR) indicates that compliance could require reducing irrigated ground water allocations by roughly a third throughout the river basin.

Both proposals to reallocate water from Nebraska to Kansas could pose potentially sizable economic losses in Nebraska's Republican River Basin. Under the Kansas proposal, converting 515,000 irrigated acres to nonirrigated production leads to a direct economic loss of $58.7 million (Table 2). Under the Nebraska alternative, water allocations would be reduced by roughly a third on all irrigated acres in the Republican

River region. Using a water optimization model, the direct economic loss of reduced groundwater allocations could reach $59 million as irrigated corn production declines and is replaced with increased nonirrigated wheat production (Appendix A).[13]

According to an input-output model of the Republican River Basin, total economic losses could reach $73.9 million due to reduced business and household spending. Based on the economic links between industries, the model estimated a total economic multiplier of 1.25, consistent with previous Republican River Basin studies (Thorvaldson and Pritchett 2006; Thompson). The multiplier indicates that, for every dollar loss from reduced irrigation, total economic losses would be $1.25—one dollar from direct economic losses and 25 cents from spillover effects. As a result, direct economic losses of $59 million could lead to total economic losses of $73.9 million, with spillover effects from reduced business and household spending of $14.7 million per year. Total economic losses would account for roughly 5 percent of the Republican River Basin's $1.5 billion in value-added activity, where value-added activity measures the additional economic income or value generated from production activity above and beyond the cost of inputs, similar to the gross domestic product measure at the national level.[14]

Under the Kansas and Nebraska proposals, both the cash rent and optimization model analyses result in similar estimates of economic loss. However, this is usually not the case as the size of the direct economic impacts often varies by the analysis used. For example, assume water markets completely eliminated irrigation in the region by transferring all of the water rights from agricultural use to an alternative use outside the region. In this extreme case, if all 973,000 irrigated acres in the Nebraska Republican River Basin were retired and converted to nonirrigated production, direct economic impacts could approach $111 million, according to cash rent analysis. The water optimization model, however, suggests that direct economic losses could reach $225 million if water allocations were eliminated (Table 3).[15] Such disagreements over the size of the direct economic effects are often the barriers to solving water conflicts.

Moreover, the indirect economic effects are often imprecisely measured for a variety of reasons, creating further barriers to solving water conflicts. First, input-output models and their multipliers do not ac-

Table 2

ECONOMIC IMPACT OF REDUCING GROUNDWATER ALLOCATIONS IN NEBRASKA'S REPUBLICAN RIVER BASIN

Kansas Proposal (Cash Rent Analysis)		*Nebraska Proposal (Water Optimization Model)*	
Irrigated Acres (Thousands)[A]	515	Total Net Returns (Million dollars)[D]	
Irrigated/Nonirrigated cash rent difference[B] (Dollars per acre)	$114	Current water allocation Reduced water allocation	$473.1 $414.1
Direct Impact (Million dollars)	$58.7	Direct Impacts	$59.0
Total economic impact (Million dollars)[C]	$73.4	Total economic impact (Million dollars)[C]	$73.8
Spillover Impact (Million dollars)	$14.7	Spillover Impact (Million dollars)	$14.8

[A]For a brief description of the Kansas Proposal, see Aikens (2008)

[B]Nebraska cash rent information for southern Nebraska obtained from Johnson (2008)

[C]Economic multiplier of 1.25 used to calculate total economic impact.

[D]Appendix A provides more details on the water optimization model results

count for the economic effects of "forward" linkages emerging from reduced crop production, which reduce the need for storage, transportation, processing, and feeding grain (Thorvaldson and Pritchett).

Second, the indirect effects do not account for the value of nonconsumptive use, primarily recreation and environmental use from water diversions (Young; Renzetti). For example, based on 2006 data, the economic value of water from angling and rafting on various Colorado Rivers ranged from $18 to $358 per acre-foot (Loomis).

Third, input-output models are static in nature and do not allow for changes in local labor availability over time (Young). Research indicates that the spillover effects of water markets and transfers depend on how people respond to reduced economic activity in the community. In the face of water restrictions and reduced economic activity, people could decide to leave rural communities in search of alternative economic opportunities, leading to an income flight. If large migrations occur, per capita welfare in the community would decline; alternatively, if people remain, per capita welfare would rise (Bourgeon, Easter, and Smith).

Nonmarket mechanisms to offset spillover effects

Given the challenges to estimating the direct and indirect impacts of reduced water allocations and the barriers they present to solving water conflicts, a benefit of water markets is their ability to compen-

Table 3

ECONOMIC IMPACT OF NO IRRIGATION IN NEBRASKA'S REPUBLICAN RIVER BASIN

Cash Rent Analysis		*Water Optimization Model*	
Irrigated Acres (Thousands)[A]	973	Total Net Returns (Million dollars)[D]	
Irrigated/Nonirrigated cash rent difference[B] (Dollars per acre)	$114	Current water allocation	$473.1
		No water allocation	$248.6
Direct Impact (Million dollars)	$110.9	Direct Impacts	$224.5
Total economic impact (Million dollars)[C]	$138.7	Total economic impact (Million dollars)[C]	$280.6
Spillover Impact (Million dollars)	$27.7	Spillover Impact (Million dollars)	$56.1

[A]Irrigated acres obtained from USDA
[B]Nebraska cash rent information for southern Nebraska obtained from Johnson (2008)
[C]Economic multiplier of 1.25 used to calculate total economic impact.
[D]Appendix A provides more details on the water optimization model results

sate water right holders for their direct economic losses. However, rural communities would continue to face spillover effects due to reduced spending by businesses and households. These effects could be offset in a number of ways, including transfer payments, water taxes, or regulations on water use (Loehman and Loomis).

Transfer payments, or subsidies, from regions receiving water rights to those relinquishing them could offset the economic losses in rural communities. Conceptually, regions receiving water earn positive spillover benefits through increased business and household spending. Given the improved efficiency of water allocation to higher valued production, these positive spillover benefits should be greater than the losses in the region relinquishing water rights. With transfer payments, the economic losses in regions relinquishing water rights could be offset, and regions receiving water rights could still enjoy increased economic activity emerging from the efficiency gains of water allocation.

Water taxes could be used to account for the spillover effects and compensate rural communities. Conceptually, a water tax could be placed on any water right transfer that would be equal to the loss of public benefits (spillover effects) associated with the transfer of water (Loehman and Loomis). By increasing the cost of purchasing water rights, the tax would reduce water transactions and maintain water in the rural community for public use. Moreover, if a water transaction occurs, the tax payment to a public institution compensates the community for lost public benefits.

Regulations that restrict water use are another way to account for the public value of water. Limits or restrictions on water right sales could be used to preserve water in rural communities. For example, a public institution could be given control of a portion of the existing water rights to preserve water access for public use in the community. Research indicates that to compensate for environmental and third-party spillover losses, up to 25 percent of the water many need to be transferred to public control (Zilberman and Schoengold). The challenge with transfer payments, taxes, and regulations is measuring precisely the indirect effects and identifying the appropriate level of payment, tax, or regulation to offset these impacts.

IV. CONCLUSION

Water has shaped the economic fortunes of many rural communities. Over the past decade, drought has strained water supplies throughout the district. At the same time, increased urban demand is outpacing current water resources. Throughout the district, conflicts have arisen over water reallocations and their associated economic effects.

Water markets improve the efficiency of water allocation by transferring water from low-value to high-value use. But uncertainty regarding the economic impacts of water transfers on rural communities has limited the implementation of water markets. Thus, information on the economic effects of water reallocation and improved methods of estimating the economic losses of transferring water outside rural communities are sorely needed.

Water markets have emerged as a preferred way to allocate water. Markets not only improve the efficiency of water use, but they also compensate existing water right holders—farmers—for their direct economic losses from reduced irrigation. Still, markets struggle to account for the public benefits of water use or the spillover effects of reduced household and business spending. Nonmarket mechanisms, such as transfer payments, taxes, or regulations, may be needed to account for the public benefits and spillover effects of water reallocation. While not perfect, the implementation of water markets can be a major step in solving the conflicts over water reallocation.

Appendix A:

ECONOMIC LOSS IN NEBRASKA'S REPUBLICAN RIVER BASIN WITH REDUCED OR ELIMINATED GROUND WATER ALLOCATIONS

Natural Resource District	Ground Water Allocation (inches)	Net Returns per Acre (dollars)	Total Irrigated Acres (thousands)	Total Returns (million $)	On-Farm Economic Loss (million $)	Off-Farm Economic Loss (million $)	Total Economic Loss (million $)
Lower Republican	9	508	248.2	126.1			
	6	447	248.2	110.9	15.1	3.8	18.9
	0	277	248.2	68.8	57.3	14.3	71.7
Middle Republican	12	484	352.4	170.6			
	8	422	352.4	148.7	21.8	5.5	27.3
	0	251	352.4	88.5	82.1	20.5	102.6
Upper Republican	13	473	373.1	176.5			
	8.5	414	373.1	154.5	22.0	5.5	27.5
	0	245	373.1	91.4	85.1	21.3	106.3
Total	Current		973.7	473.1			
	Reduced		973.7	414.1	59.0	14.8	73.8
Total	Eliminated		973.7	248.6	224.5	56.1	280.6

Calculations based on University of Nebraska Water Optimization model. Franklin, Hayes, and Chase counties were used as the representative counties for the Lower, Middle, and Upper Republican Natural Resource Districts.

An input-output model of the Republican River Basin indicates an economic multiplier of 1.25.

ENDNOTES

[1]The Tenth Federal Reserve District encompasses the states of Nebraska, Kansas, Oklahoma, Colorado, Wyoming, the western third of Missouri and the northern half of New Mexico.

[2]In the Tenth District, the source of irrigation water varies by geographic location. In the Plains, ground water is the primary source of irrigation water, accounting for 96 and 92 percent of the irrigation water in Nebraska and Kansas in 2000, respectively. In the mountains, surface water is the primary water source, accounting for 90 and 81 percent of irrigation water in Wyoming and Colorado in 2000, respectively, fed by mountain streams and run-off from winter snows.

[3]An acre-foot is the volume of water needed to cover an acre of land to a depth of one foot. State and county level water use data are available from the U.S. Geological Service, *http://water.usgs.gov/watuse/*.

[4]Recent estimates indicate that roughly three gallons of water are required to produce a single gallon of ethanol, down from six gallons of water a few years ago (Keeney and Muller). Increased ethanol production and the resulting higher corn prices have also led to an increase in water demand as more irrigated acres are planted to corn, a crop that uses more water than other types of crops.

[5]Thermoelectric and hydroelectric power generation is generally considered to be non-consumptive as water is ultimately returned to stream flows.

[6]For example, in 2006, the state recreation area at the Ogallala Reservoir in Nebraska had 808,000 visitors during 2006, with 70 percent of them out-of-state visitors (What's Sport Fishing Worth).

[7]Information on the Platte River Program, USGS Priority Ecosystem Program, is available at *http://ne.water.usgs.gov/platte/*.

[8]Both surface and ground water sources are used to provide public service water in the district. In 2000, over 80 percent of Nebraska's public service water came from groundwater sources, while 94 percent of the public service water in Colorado came from surface water sources.

[9]According to the Transboundary Freshwater Dispute Database at Oregon State University, *http://www.transboundarywaters.orst.edu/database/*, Tenth District states participate in 22 separate water compacts, with some dating back to 1922.

[10]Under prior appropriation, water rights are independent of the land where the water originates or where it is used, as the water is typically diverted from the source. Appropriated water rights can be sold, transferred, leased, or mortgaged separately from the land if allowed by state regulations.

[11]A comprehensive assessment of the various methods used to analyze the economic value of irrigation is provided in Chapter 5 of Young. The methods include both inductive and deductive techniques ranging from hedonic property value, optimization, and willingness to pay, to representative farm models.

[12]Young (2005) provides a critic of input-output models used to analyze the economic impact of water. One drawback of input-output models is their

static nature, which does not account for the ability of economic participants to substitute other goods and services into their production functions, nor do they account for resource constraints.

[13]In 2006, studies analyzing the effect of smaller reductions in irrigation in Nebraska's Republican River Basin found consistent results. Assuming 14 to 18 percent reductions in water allocations across the Republican River Basin, annual costs were expected to reach $20.7 million per year (Supalla, Buell, McMullen). When 118,000 acres of irrigated land was transferred to non-irrigated use, total direct and spillover costs were expected to reach $14.7 million (Supalla, Buell, McMullen). When irrigated cropland in the river basin was to be laid fallow, direct and spillover effects were expected to reach $81 million annually. (Thompson).

[14]Using 2005 IMPLAN values inflated to 2007 dollars, total industry output in the Republican River Basin was $3.3 billion and total value added at $1.5 billion, with value added activity from crop production at roughly $440 million.

[15]The large difference in farm sector losses between cash rents and optimization models could reflect the fact that the $114 per acre cash rent difference incorporated nonirrigated acres with and without irrigation potential. Statewide in Nebraska, nonirrigated land with irrigation potential has a higher cash rent than land without irrigation potential. If a water market eliminated potential irrigation, the expected $114 per acre loss would be too low.

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