Extended Abstract for AMS 2003 Annual Meeting, Symposium on Impacts of Water Variability: Benefits and Challenges; paper number 8.5

TITLE: Water banking as institutional adaptation to climate variability: the Colorado experiment

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Why transfer water?

To start with the conclusions, the ability to transfer water to more valued uses is a critical part of the ideal responses to increased climate variability, as well as highly desirable under present conditions. But, institutional friction is very high, so the new Colorado experiment of the Arkansas River Water Bank Pilot Project (C.R.S. 37-80.5-103) is potentially important. Without institutional change, such as the "water bank", there is very limited ability for agricultural water rights owners to do anything but "use it or lose it". In the Western states, the majority of water consumption is in agriculture, and transfer from it is the alternative to "new water" developed by other means. New supply is decreasingly feasible, as remaining opportunities are increasingly expensive.

There is a basic economic principle: there are gains to both willing sellers and willing buyers, and to the economy as an aggregate if resources are put to a higher-valued use. (See Easter et al. 1998, Howe 2000, 1998, 1997, Howe et al. 1986a, 1986b, Western Water Policy review Commission 1998, National Research Council 1992, Saliba and Brush 1987.) This year, before conservation pricing was put into effect by many cities, "retail" water was provided by Aurora for about $650 per acre-foot (Denver Post May 7, 2002). Many agricultural users are faring badly with water from direct flow water rights, with no charge per volume, and "project water" for which they pay storage charges and fees under $10 per acre-foot.

In addition, it is sensible to consider increased flexibility in management as a way to respond to increased variability in climate (see Adams, 1999, National Assessment products from USGCRP, for example the Water Sector report available at: <http://www.gcrio.org/NationalAssessment/water/water.pdf> , and IPCC Working Group II, 2001).

The term "water bank" is used generically, to refer to a mechanism for reduced-cost transfers, and not to a government-capitalized entity charged with acquisition of water and sale to others, as in the California program between 1991 and 1996; Easter et al. 1998, Jercich 1997). Because the California project was so well- known, the term has spread, even though it is not correctly applied to a majority of cases where an institution is created to allow fast and low-cost transfer of water.

From the oral presentation, here are some context-setting figures to go with the map and illustrations of ditches presented.

Where does the water go?

Average Water Withdrawals by Owner in the Arkansas Valley

CITIES	
Colorado Springs	76,000 acre-feet
Pueblo	38,659
Aurora	35,459
Canon City	5,703
Pueblo West	3,100

Florence	2,067		
Lamar	900		
Municipal Use Total		161,888	(11.97% of CO use)
Kansas State Line Flows		192,358	
Rocky Mountain Steel		76,779	(5.68% of CO use)
Agriculture, Irrigation		1,113,647	(82.35% of CO use)
TOTAL used from Arkansas River		1,544,672	

(From Frying Pan-Arkansas, trans-mountain diversions used by SEWCD average 69,200 acre-feet; SEWCD Annual Reports.)

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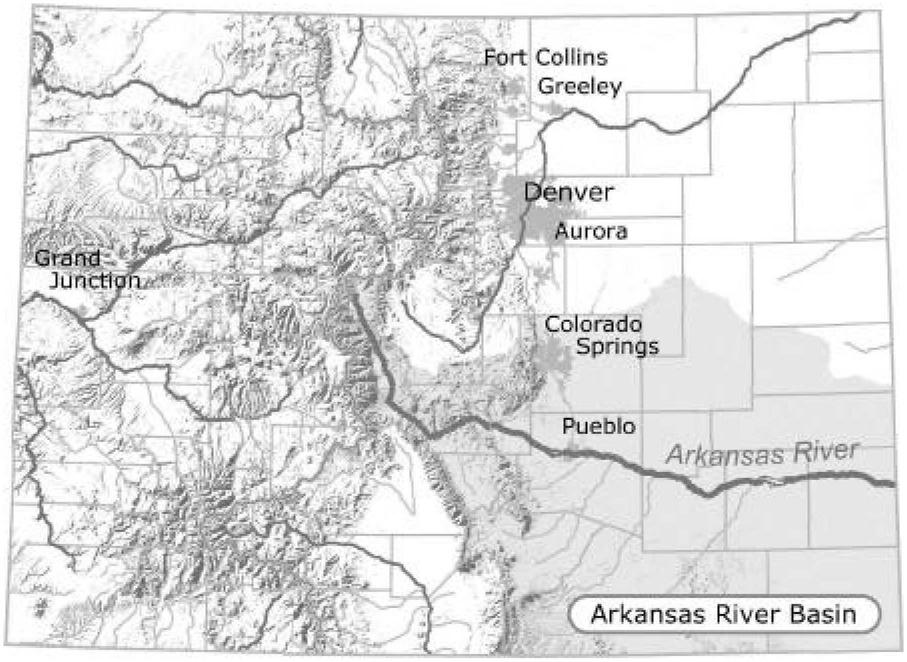
WITHIN IRRIGATION AND AGRICULTURE (* indicates interviewee)

Lower Arkansas Water Management Association	9,112
Arkansas Groundwater Users' Association	2,795
FORT LYON IRRIGATION AND STORAGE CANALS	339,672 *
Colorado Canal	119,167
CATLIN CANAL	116,725 *
Rocky Ford Highline	101,566
Amity Canal	107,170
Bessemer Ditch	70,981
Holbrook Canal	55,653
Lamar Canal	54,034
ROCKY FORD DITCH	36,834 *
Las Animas Consolidated (Public Service Co.)	33,225
Oxford Farmers Canal	30,816
Buffalo Canal	23,345
Fort Bent Canal	20,852
X-Y Canal	10,572
Otero Canal	9,507
Keesee Ditch	7,373
Hyde Ditch	3,334
Manvel Ditch	914
Total	1,113,647

These figures are good for about 1998-1999; they are provided strictly for illustration purposes, since they are subject to change for many reasons. A great deal of concern over previous transfers came to bear in response to the attempted purchase of the Ricky Ford Ditch by the City of Aurora – this took place in two parts, one completed, shown by Aurora's consumption in the cities listing, and the second part currently in Water Court proceedings. The situation is very complicated, and well beyond the scope of this abstract. But the attempt created a great deal of concern over impacts to the local economy and future lost opportunities.

The Arkansas Valley is unusually dependent on agriculture, though Colorado's largest industrial establishment in the past, Colorado Fuel and Iron's great steel works, is in Pueblo; but it is now radically down-sized, in different ownership, and subject to a very long bitter labor dispute. Pueblo is undergoing a revival based on its very pleasant climate and smaller size compared to the highly congested and very expensive Colorado Springs and Denver Metro areas to the North. Still, until 2002, Pueblo regarded itself as well supplied with water (for details, see the Pueblo Chieftain newspaper on-line. The Arkansas River case is an example of a fairly large set of cases worldwide, and even U.S. West-wide.



Locator map – the Arkansas River Basin in Colorado

Existing water transfer mechanisms

There are also a variety of existing "water banks" in operation, with various wrinkles in the rules and the coverage they provide (Easter et al. 1998, National Research Council 1992, Saliba and Brush 1987). The critical limitation on most of them is that they avoid the complexities of property rights in return flow by operating only with specific sets of water resources. Many are limited to groundwater from identified aquifers, and act to allow trading between users, as in Arizona and Nebraska; some work with waters stored and pumped in an alluvial system, as in Idaho (see also MacDonnell et al. 1994).

Another form of easy trading takes place with water which is "imported" from another basin, relatively recently, and exempted from normal ownership rules. The premier example in Colorado is the Northern Colorado Water Conservancy District, (see <http://www.ncwcd.org/>, and see Western Water Policy Review Commission 1998), where water is easily transferred, and has gradually shifted to larger shares of municipal use. There is also ready transfer within some irrigation districts supplied by the Bureau of Reclamation, also because of special ownership situations where the Conservancy District created to act as the client for the project owns the return flows and so can allow easy transfers within the district. But, there is no general water bank yet, because of complexities which require a short "primer" for those new to this area.

Primer: The 5 kinds of water and Western prior appropriation water law

The simplest useful approach may be to consider 5 "kinds" of water under the "prior appropriation" system.

- Normally, one thinks of a right to divert some flow from a stream; this is limited in flow rate, and sometimes in time during which the right can be used. This is a "direct flow" water right.
- The second kind is "stored water", in a reservoir, and there is a different kind of water right to store water.
- The third kind is ground water – springing or pumped in order to be used, and this can be divided into water known to be tributary to surface waters, or non-tributary water which is

thought to be hydrologically unconnected to any flows in which others may have a property right – much of this is deep "fossil" water.

- Fourth, there is "return flow" water, which is water that has been applied to a use, usually irrigation, and not consumed. For example, about half of the water diverted from the Arkansas by the big ditches is commonly "return flow" – which "makes the river" below the ditch. That means that someone downstream has a property right in that water. Arkansas River water is thought to be used 5 times before it gets to Kansas. The return flow is what is not consumed by plants and evaporation. The "consumptive use" is what you can legally transfer – it is the beneficial use to which you can get a water right, in general. Exceptions include special in-stream flow water rights for environmental and amenity purposes, and in Colorado, recreational in-channel flow rights for boating courses. The critical point is that the return flow is not transferable, because someone else has a right to it.
- Fifth, all those kinds of water are "native" to the basin; the last kind is "trans-basin" water; this is diverted from another basin and has special legal status. The client conservancy district or irrigation district authorizes use of the water but retains the rights to the return flow. The rationale is that this is foreign, and can be brought in under special conditions because no one could have appropriated it before it was present. The principle is that there were no expectations for this water, unlike native water.

Property Rights, Beneficial Use, Conservation

The idea of expectations is central to property rights, and the prior appropriation system. In a very small nutshell, one of the benefits of a property right is that exchange is possible when the seller and buyer can identify a thing, and what the limits on its use are. In the case of a flow, the "prior appropriation" system used in the Western U.S. generally allows a water user to claim a property right to a specific flow, usually by rate of flow and sometimes limited by time. The "priority" element is essential to a meaningful property right, and is a fundamental adaptation to climatic and hydrologic variability. The first recognized water right has first priority, and it will be fulfilled before the second right, and that before the third, and so forth. The oldest water rights have highest priority and highest reliability, and thus highest value per unit of water or flow. Buyers know the meaning of the priority date, under the "normal" climatology, and if change is detected or becomes predictable, that information will also change water values.

The water itself is doctrinally or constitutionally claimed to be public property, and the use from a water right is limited by the idea of "beneficial use". It be impossible to have a water right for a use not recognized as beneficial – this is what prevented people from establishing in-stream flow rights until specifically recognized as a legitimate use by legislatures. And, the limit on the right is the amount beneficially used – which by definition does not include the return flow. So the flow that gets back into the alluvium or river can be appropriated by someone else, which maximizes the beneficial use of water and the public benefits. (For a larger nutshell, see Getches 1997; more detail on Colorado is available from Corbridge 1998, Corbridge and Rice 1999).

There is a serious problem, however, from a very practical approach developed in the 19th Century, with little technology available for ground water engineering. The amount of water that became return flow was very hard to establish. Therefore, a party wanting to make a transfer would have to bear the heavy burden of showing the amount that should be legally transferable, and anyone with an interest potentially harmed could require that proof. Cities with taxing authority could easily do this; small farms and ranches often could not. This added to the strong one-way pressure for water transfer from agriculture to urban and industrial uses.

There is a second consequence, however, with important negative effects on efficiency. That is that if a farmer wants to transfer water from one use to another, she must show "no injury" to others. Suppose a typical flood irrigation system, or furrow irrigation. Return flows may be more than half the diverted water, and the amount actually used by the crop may be well under the half "consumed", due to evaporative losses. Ideally, a farmer would like to use the water more efficiently – there are various ways to use it with much less loss, though expenses are often quite high (Central Plains Irrigation Association 2002). There may be two real stumbling blocks to this.

If the farmer decides to use a high-efficiency, low-loss system, such as subsurface drip irrigation from porous tapes delivering water and fertilizer right to the roots of a crop, then by definition the beneficial use of irrigating that acre is being met with the much lower volume of water. The water right can be reduced to that, under the principle of beneficial use. Some farmers have done it, but others have decided that they can't risk losing their water rights, since they may be much more valuable than the farm. (One of our informants said, "When I bought my water, the land and farm house were a throw-in.") This is widely thought to prevent adoption of efficient water uses, and there are often calls for "salvage" or "conservation water" protection, to remove this disincentive to conserve.

The second problem is that if the farmer decides to apply the "saved" water to new ground, irrigating another field, there will be some increase in consumptive use from evaporation – new surface – and more plants. So, logically, one needs adequate quantification of the change in consumptive use, and the changes in volume and timing of return flows, so as to assure that there is no injury to other users. This is a great deal more easily said than done – hydrology is simpler and clearer at larger scales than farms and local alluvium, and there is that burden of proof to be borne. The water can be transferred – but not easily and cheaply. And the farther away, and the larger the volumes involved, the more expensive, up to a point.

In fact, past a certain scale of transfer, the costs per unit decline, and this favors very large transfers, such as those to cities – big lumps rather than little increments (Howe 2000, 1998, 1997). This in turn means that there are high secondary impacts on local economies from the losses of primary income from lands that just go out of production. In the Arkansas, land with a long history of irrigation may be unusable for dryland or grazing purposes after salt-flushing ceases, due to high salinity and high water tables; this is locally variable but all post-irrigation uses for agriculture alone are less economically productive.

Transactions costs – in these cases, everything from publishing notices in local newspapers, to attorneys, engineers and water court proceedings, are high to start with, and too high to allow a lot of transactions to be economical. But a lot of little losses add up to some big ones, looking at the system as a whole. These impacts may fall hardest on those who can least afford it – those whose major asset is in fact their water rights. This may be a large efficiency loss under any climate situation.

The impacts of this, in turn, include the secondary economic impacts on small towns that are affected, and a variety of subtle impacts, also. Among these are the pressure to fragment habitat, from sale of attractive parts of land-holdings, affecting wildlife, winter forage, and biodiversity in wetlands and riparian zones. Pressure to subdivide lands to "cash out" results in increased expenses for many public services and land fragmentation and roading, and with increasing density of "ex-urban" settlement, changed rural character and attitudes toward agriculture (sometimes combated by "right to farm" laws).

Interstate compacts are also a critical limit on total consumptive use. The amounts promised from Colorado, the headwaters state, to other states are defined differently in each compact, but the relevant point is that they set a limit on consumptive uses allowed. Within that limit, transfer are supposed to be a zero-sum game.

Result: Transactions costs versus flexibility

The problem of high costs to move water from one use in one place to another use or another place of use has long been thought to create important inefficiencies and mis-allocations (Western Water Policy Review Commission 1998, National Research Council 1992, and most of the references cited). The before versus the after are a strong argument for transfer from low-return uses in agriculture to high-value uses in cities, but the processes of making the change have always been problematic (see especially Howe 2000). Western water rights are transferable, but the protection of other water rights holders and the mitigation of environmental and public-good externalities have made the process expensive and slow. This has prevented many small transfers, which costs efficiency within the agricultural sector, and it has prevented many short-term and reversible transfers out of and into agriculture, also reducing over-all efficiency.

With increased climate variability, the value of quick and low-cost response capability also increases, perhaps particularly for small low-capital operations with limited financial resilience.

Six kinds of paradigm transfers:

The increasing pressure for transfer of water from agriculture to urban use increases the desirability for a transfer process that allows for lower-cost and reversible transfers, as well as ways to "right-size" and "right-kind" the transfers. In terms of the Arkansas, and perhaps in general, Wiener argued to the State Engineer that there are roughly 6 kinds of desirable transfers (comments on rulemaking):

- Local Efficiency – transfers from one farm to another, for more valued use, on the same ditch.
- Pooled efficiency – aggregation of transfers from several farms to another use.
- Relocation within an operation – moving water to better soil or better technology.
- Relocation between operations, including moving water from one ditch to another or another use.

These are clearly variations on the simple theme of being able to move water for mutual benefit, and they are distinguished for local purposes; we have reason to think that the first kind, for example, is much more common than is publicly known; the second would be very advantageous for use with a water bank, and would be a novelty (disregarding for a moment the role of ditch companies); the third runs into serious opposition due to common understanding (which I think is incorrect) about the limits of expansion of use of water under the interstate compact governing the Arkansas River; and the fourth is also something of a novelty.

- Dry-year options, long-term interruptible supply contracts which move water under specified conditions, for specified fees, which might include signing bonuses, annual payments, and graduated payments per unit of water depending on the time of exercise of option, or expenses incurred or required to mitigate effects of transfers.
- Finally, the inclusion of public interests, as a way to internalize some public benefits into transactions, could include multi-party rearrangements, including conservation easement sales and packaging, easements for access for hunting, fishing, recreation, trails and greenways, flood management, wetlands restoration and banking, and so forth. Salinity reduction would be an excellent public good outcome, which might warrant public investment (and in fact would probably be recoverable from increased productivity if carefully handled).

So what? Why would you want to do any of this? Finally, some climate issues (thank you for your patience!) All of these are now possible, at least with stored water, under the rule-making.

Three ways to apply climate information

Dry Year Options:

These are long-term contracts, as described just above; they are intended to be used in place of permanent "sell-out" and loss of irrigation use ever after for the lands from which water is sold. Permanent transfers have different effects from those which will take effect only in dry years, but so far the legal and engineering costs of "interruptible supply contracts" or "dry-year options" have been so high that cities considering them have just gone ahead with permanent sales of water rights, and leased water back to agriculture as convenient (interviews with Broomfield, Boulder, Thornton, Westminster officials, 2002). The Northern Colorado Water Conservancy District has also considered the problem (interview, 2002). No one is against the idea, and everyone appreciates the value to agriculture of retaining the property right, even subject to loss of use in some years. But, the legal threshold of being first to do it is likely to be a high expense, high-effort trip to the Colorado Supreme Court, and it would be essentially a gift of that expense to the agricultural community from the citizens of whatever municipality decided to make it. Instead, cities just buy the water rights, and lease the water back to agriculture when it is not needed. This involves the same transactions costs, and more advantages in the additional flexibility for the city. There are also some other options for "emergency" temporary water supply plans (recently enacted HB 1414, and associated rule-making.)

But, where drought increases the need for municipal water supply, as it did rather dramatically in 2002, there may be more will to make unusual deals. At the time of writing, there is little formal information available about the ways cities acquired more water; anecdotally, it has been a time of serious pursuit of agricultural water as leases for this year, and apparently, for 2003 as well.

The long-term climatology surely will help inform people considering dry-year options, since the municipalities want very long-term commitments. The reasoning is that the cities "sell a tap forever" – so they need supply commitments for a long term. But they are also interested in the potential cost-savings from increasing supply in dry years only, when there is by definition very little need for additional infrastructure. No new storage is needed, only some new connections in some cases. The benefits in theory would be the savings from avoiding the next-cheapest source of supply.

Pre-Season Planning:

There are substantial opportunities for benefits for agriculture from pre-season planning. For any given year, if institutions allowed, it would be ideal to be able to lease water, and to reasonably well estimate the demand compared to the supply. With some degree of knowledge of the likely supply, it becomes more attractive to invest in water-intensive crops, anticipating larger supply, or perhaps to plan low-water crops and transfer some water for a guaranteed return no matter what else happens. One can easily imagine the range of possibilities, and how they can incorporate improved knowledge of one's own growing season, that of the likely competitors, and one's own farming or ranching conditions. In regard to knowledge of competitor conditions, for example, several farmers mentioned that if other places with lower costs of production were going to have a good year, they wouldn't compete in onions. On the other side with widespread drought there has been very high demand for alfalfa and hay and prices have been much higher than normal this year. The producer must match the uncertainties of the yield with the uncertainties of the financial and price outcomes from the larger markets.

Two agronomy considerations make the use of pre-season planning attractive. One is the availability to select different cultivars; corn (maize) can be had with 80 to 150 day growth periods. For instance, for the sweet table corn market, there are much better prices for the earliest and the latest fresh corn. For the feed corn markets, timing is much less important. The other is the difference in when crops need water is also important; spreading out the critical growth stages by different choices may mean the difference between success and failure with the same water supply. Current research in agricultural extension in Colorado and Nebraska includes efforts to identify and teach the differences between providing less-than-ideal water supply during vegetative growth stages versus reproductive growth stages, and relating yield differences to finances (Central Plains Irrigation Association 2002).

In-Season Re-allocations:

Another set of possibilities comes from the increasing ease of use of irrigation scheduling computer models. Hanley et al. 2002 provided a good review of some fairly high-end modeling work, at last year's AMS, and this suggestion is pitched at a somewhat different target. One of the problems faced by downscaling efforts is the problem of localizing the results for terrain and the hydrologic responses of different soils. And, the time scales involved are important. One way to partially "end-run" some of the problems is to work with localized (farm-specific or even field-specific conditions) inputs, and shorter time-scales. Using models now available that run very quickly on desk-top computers, one can input continuous updates of precipitation received, and even (soon, perhaps) adjustments for evapotranspirative losses. These are distillations available for free on internet from sources such as the Cooperative Agricultural Extension Service of Colorado State University and USDA (Central Plains Irrigation Association 2002 and see <http://ccc.atmos.colostate.edu/~crop/>). This means that the rest of the season can be reasonably modeled. It will be possible to use this kind of tool to input forecasted conditions, to see how things would play out, as well, with translations from climate forecasts to hydrology that are becoming more feasible, as other papers in this symposium are showing.

It will soon be considerably easier to compare expectations based on current conditions and current prices for future crops, and prices for water, to consider in-season reallocations. Here, quick and low-cost water transfers are especially important. Farmers with low-value crops may realize higher returns from transfers to those with high-value crops in need of additional water, if weather changes adversely impact supply or soil moisture. Ability to use the increased evaluation capacity, however, depends on being able to make the transfer. Currently, there may be high flexibility on a very local scale, such as on the same lateral or nearby on the ditch, but larger areas within which trades can occur would include larger variations in productivity and probably potential gains from trade.

Increased Incremental Flexibility:

The current lack of flexibility in whether or not to use all available water, and difficulty of changing the rate of return or productivity from use, may thus be eased by the combination of new information and the ability to respond to it. Presently, there is limited ability to incrementally adjust operations, before or during the year, because of the fear that declining use of water rights risks losing them, and the lack of useable temporary transfers for many potential participants. Municipal buyers or lessors can easily accommodate additional shares of a ditch company's supply, for example, where the effect is to increase the city supply back upward to where it had previously been, so new connections or conveyance are not required. Where there is no new plumbing needed, things are faster. But even here, many of the transfers that interviewees mentioned were possible with little new information needed simply because there had already been substantial investment in quantifying the transferable amounts for similar transfers. These conditions do not often apply to agriculture-agriculture transfers.

The Engineering Needs

The lack of transactions in water in many places means that there may be very little existing information on the return flows, suitable for quantification of the transferable fraction of a water right. This is critical for defense of the pattern of return flows required to maintain legally vested water rights. When a transfer is sought, the water court will normally hear testimony based on local investigations as well as review of adjudicated water rights, and other change applications; in fact, one of the objections raised to the Water Bank Pilot Project was that it takes so much work to do this that some objectors believed it impossible for the State Engineer's office to quickly review proposed transactions. The counter-argument, however, was that there had to be some level of adequate engineering estimation to make this work, even if there was some error, and that this was on offer. The reversibility of changes is an additional persuasive factor.

in the objectors' decisions to not challenge the new rules, as of October 2002. (The rules are available at <http://water.state.co.us/pubs/rule_reg/arkpilotrules052302.pdf>, and see <http://water.state.co.us/pubs/rule_reg/arkriverbasis.pdf>.)

The core issue was whether the "acceptable factors" for calculation of transferable consumptive use would be acceptable. Legally, these are rebuttable presumptions, and the question is who bears the cost of proving them wrong (an objector) or right (a party seeking the change). The expense of making a proof either way could be substantial, so the lack of protest or litigation is an important accomplishment, which reflects the potential benefits if this can be made to work. Another way to consider this is a new agreement that the risks are worth the experiments with temporary transfers. That may sound trivial, but in the immortal words of Mark Twain, "Whiskey's for drinkin'; water's for fightin'."

Although not explicitly relevant, there is also important new engineering technology and modeling being developed, and this very likely affected the outcome. Oddly, this comes in part from the litigation by Kansas versus Colorado, over claimed failure to meet the interstate compact obligations. This has resulted in an extremely high level of monitoring on the Arkansas River. In addition, there has been excellent new research on salinity, on the regional and the field scale (Gates et al. 2002). The social acceptance of the adequacy of engineering "off the shelf" is likely to be higher than previously, and the expectation that mistakes causing injury will be caught is reasonably high, as well.

The Colorado Experiment

Governor's Commission crystallized response

Colorado's very rapid urban growth has resulted in quite large transfers, resulting in significant public concern over impacts to agriculture and areas of origin. The Governor's Commission on Preserving Open Space, Farms and Ranches (2000), in turn stimulated several legislative responses, including the bill which authorized the Arkansas River Water Bank Pilot Program.

Rule-making successful, necessary but not sufficient

The legal innovation has been formally established, and the Office of the State Engineer has drafted the rules to allow maximum use of climate information. The experiment continues until 2007, but the real period of interest is now through early 2005, because a comprehensive report on the pilot program, including prospects and problems for water banking, is to be written for the legislature. The rules are remarkably good, given the very tight time under which they could be written and moved through the rule-making process. Among the successes in the rule-making are provisions which allow pooled efficiency transfers, or aggregation of contributions, and careful wording which allows dry year options using climate triggers or contingencies, and no prohibition of multi-party transfers and rearrangements. The ability to relocate water to better soils without additional engineering will probably require a court test, due to questions of how the Arkansas Compact applies.

Social processes, making a market, and drought

But the rule-making took place in a year during which a parade of threats to Arkansas water users marched ahead with the effect of preventing anyone from beginning the social processes of institutional innovation and engagement with the critical players whose support will be needed for there to be a fair trial of the new opportunities. The parade included the first-ever serious negotiations over mitigation payments to public entities in the Arkansas Valley over secondary economic impacts, including but not limited to lost tax base and school funding due to transfer of water from the Rocky Ford Ditch to Aurora (a fast-growing large city east of Denver); this involved dealings in the legislature on whether or not to require such mitigation, and a great deal of negotiation over who would get what.

Just as that was settling down a bit, news came out of a private campaign to secretly acquire 20 percent or more of the Fort Lyon Canal, by far the biggest in the Valley. This could move more water than the highly controversial Rocky Ford Ditch sales, and the news was ripe with threatening details such as the involvement of a notorious disbarred attorney, mystery principals, and undisclosed buyers of the water, and reportedly success in getting more than 20 percent under option (in June a county commissioner stated that 68 farms had been sold; other reports claimed 23 percent and likely to increase).

With that for Christmas, the City of Pueblo effectively shut down the pending U.S. House legislation (H.R. 3881) on reoperation of the Frying Pan-Arkansas Project, with feasibility study of enlargement of the Pueblo Reservoir and other changes. Pueblo did not block the efforts to begin study of a drinking water conduit, however, which would literally be a pipeline for lower-salinity water from the reservoir down along the river far to the east, because the Arkansas salinity requires very expensive treatment for drinking water systems. However, Pueblo did seek a new recreational in-channel water right, which quite effectively raised hackles even further.

Two other big institutional changes also affected water politics. Perhaps as one result of the intense conflicts and political issues, the intended and eventual water bank operator – the Southeast Colorado Water Conservancy District – has been without a general manager for months. The District plays a central role in water management, and includes Colorado Springs, the suburbs, and Pueblo and its suburbs as well as the lower Valley. Arguing the need to keep water in the Valley, county commissioners and others have worked since last December to get a new conservancy district on the November 2003 ballot; if voted in, it would have a small taxing ability, and the mission of water preservation. How this will work is unclear, though many ideas are available; most, however, appear unsustainable.

By the time some of this was settled, the drought had become an enormous and ominous surprise; by June the big canals were literally dry and water in priority was earlier than anyone could ever recall. Things got no better over the summer.

With almost every major institutional and hydrological aspect of the river in some new and frightening condition, people fighting to stay economically alive or politically involved in their fates, paid little attention to the new rule-making. And there was no decent opportunity to seek truly meaningful input to the process from the public, because of the lack of time and attention to reiterate any steps. (Please see extended abstract by Wiener for AMS 2002 meeting, on the social process.) The hard part is yet to come. And so, as of October there has been no action, and there is no public pressure for it. The next few months may be critical for this experiment, for activity in 2003. Details of the drought are being presented in this symposium, and will be available widely in the archives of the National Drought Mitigation Center, and a variety of data sets. Here, the important point is that the major ditches were dry very early; crops are very low, herds have been very badly reduced under duress, and the pressures to sell out were probably greater than ever. (The best on-line archive for Arkansas Valley news is the Pueblo Chieftain, <www.chieftain.com>; there are local papers in each town but those with websites are much less extensive.)

The rules allow the experiment to proceed, but there has been no development of the social adoption of the institutional innovation. The threat now will be failure to establish a credible effort, in terms of making a market. Currently, there are two "markets" in Colorado water, outside of the provision of supply within a municipal service area. One is in the foreign water supplied by the Northern Colorado Water Conservancy District, in which prices fluctuate , but are reasonably discoverable (interview, 2002). The second is in shares of ditches in the Front Range metropolitan area, where past trades have established some pattern, but municipalities differ in their will to make this information available. In the end, a city's purchases are public information, but several told us they would prefer not to disclose prices paid, which surely reflects interest in keeping those prices as low as possible. We do not know how much the tight-knit water community shares, since there is serious competition. But we are fairly confident that given the very small number of potential buyers for Arkansas Valley water, until the water bank, there has been a great deal of knowledge of a very small number of high-volume sales. Now, we will need to stimulate interest in more information generation, or risk path-dependent or accidental pattern setting without much reference to economic factors (MacDonnell et al. 1994) , and perhaps in a situation of highly asymmetric bargaining power. It is quite possible that fear of this asymmetry, especially during hard times and drought, is partially responsible for widespread suspicion of the new institution. Between the time of submission of this abstract and the time of presentation at the meeting, we hope to learn more on this topic.

Public interests

There are several public interests in the outcome of the water bank experiment; in particular, the need to diversity the rural economy may be partially met by a good outcome and effective use of transferability to help reorganize riparian and amenity-rich areas for multiple and more lucrative uses. These range from trail and corridor uses, hopefully along the drinking water aqueduct and some of the access roads, and wildlife production areas for which hunters commonly pay access fees. The value of real estate is strongly influenced by riverine environments (despite flood hazards, in some cases, Wiener 1996), and also by access to trails and outdoor recreation (National Association of Home Builders real estate survey, 2002, reported by Rails-to-Trails Conservancy, and on NAHB website). The enormous importance of tourism in rural areas is likely to increase in the future, along with the economic potential from second and retirement homes. Local recreational access is also limited. The secondary impacts of lost primary income are also traditionally regarded as public interests; reduction of the rate of farm loss, and increased agricultural income from reorganization for higher productivity would be beneficial.

Salinity

Among numerous environmental issues, salinity in Western rivers is an increasing problem as the water becomes more heavily utilized. The Arkansas River reaches 4,500 mg/l of total dissolved solids at the Kansas line (for comparison, Colorado River salinity at the border with Mexico is about 1,500 mg/l and has resulted in millions of dollars in salinity reduction efforts). Literally thousands of acres are severely impacted, with yield reductions of 10, 25 percent or more, and some land is just out of production – 100% loss. At the Pueblo Reservoir, it is moderate, and the water is good for all normal purposes. By the time it gets to the state line, it is sometimes up to 4500 – 5000 ppm total dissolved solids. Cattle should not regularly drink water near this; 1500 ppm is very high for livestock. It is repulsive for people, and sometimes propulsive, as it is full of calcium and magnesium sulfates… 1500 ppm in the Colorado River at the border with Mexico requires millions of dollars of salinity reduction efforts. 1500 ppm damages almost all crops, and reductions in yields occur well below that. The critical engineering analysis shows that losses in Colorado irrigated agriculture alone may be $24 to $39 million per year (extrapolating from the study area I will show next); this work is part of a major study by Colorado State University engineering and the Water Resources Research Institute, led by Drs. Tim Gates and Luis Garcia (Gates et al. 2002). Live stock watering can be very expensive, if the water has to be from a water system, or trucked in from somewhere else or both, and this can affect cattle business success. That matters where 2/3 of state agricultural income is from livestock (Colorado Ag. Statistics, annual publication by Department of Agriculture and USDA), and in the Arkansas Basin counties, the market value of livestock in 1999 was $512 million, compared to the $197 million from farming. A water bank can help by facilitating transfers of water off the heavily salt-generating lands, and putting it to beneficial use elsewhere. Ironically, fear of being charged with "expansion of use" by Kansas may inhibit transfers which would yield significant benefits for Kansas from the reduced salinity in its water as well.

The oral presentation will report on the situation as of December 2002. We think this is an important case of trying to take theory into policy, and hope to learn through participation and observation. It is hoped that this extended abstract has suggested some of the potential value of low-cost and rapid water transfers, in a "water bank", as an adaptive mechanism to help make better responses to climate variability in the present as well as future. The Arkansas case, however, suggests that even in a state with very sophisticated water administration and a concerned and active legislature, this kind of institutional adaptation will take a great deal of time and effort. I hope scientists frustrated by apparent disinterest in their work are encouraged.

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