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ECONOMIC IMPACTS OF DROUGHT ON USES ON THE RIO GRANDE

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I would like to begin by repeating a story I heard Tom Bahr tell at a New Mexico water conference in 1982. It summarizes the difficulties of understanding, explaining, administering, and legislating New Mexico's water problems. According to Tom's story, sometime back in the 1930s, the famous British statesman Winston Churchill looked flushed after he gave a rousing and entertaining after-dinner speech. A critic alleged that Winston had consumed enough whiskey in his life to fill the room a foot deep. Winston calmly surveyed the room, mentally worked out that quantity of whiskey, and replied. "Yes, you can see I have accomplished much, but I have so much more to go." When Tom Bahr told that story, New Mexico had accomplished much in dealing with its water problems but we have so much more to go.

I would like to talk about the economic impact of the drought on water uses of the Rio Grande.

We begin today's slide show by showing the headwaters of the Rio Grande Basin starting in Southern Colorado at elevations over 14,000 feet (Fig. 1). Lower in the basin, the next slide shows the river as it approaches the Colorado/New Mexico border (Fig. 2). Here supplies from the Rio Grande Basin delivered to New Mexico are about 660,000 acre-feet in a normal year. The next slide shows New Mexico's beautiful Rio Puerco, which produces about 32,000 acre-feet in an average year (Fig. 3).

Figure 1. Rio Grande headwaters, Colorado

Figure 2. Rio Grande, Colorado supplies 660,000 ac-ft/yr (average)

Figure 3. Rio Puerco, New Mexico: supplies 32,000 ac-ft/yr (average)

In southern New Mexico, agriculture uses about 495,000 acre-feet per year. Elephant Butte Irrigation District (EBID) had a full allotment in 2002, but unless we have a very wet winter, it will ration in 2003. El Paso uses about 140,000 acre-feet per year in a full year. Mexico receives 60,000 acre-feet per year.

In the Rio Grande Basin, we have a pervasive problem of scarce and random surface supplies that is made worse during drought periods. The three states and two nations competing for this scarce supply are dealing with growing populations and growing water demands combined with the needs of endangered species as well as a lack of any comprehensive analysis of coping measures for major drought.

The map (Fig. 4) shows how the Rio Grande Compact and "Law of the River" divide the Rio Grande. Under the Compact, Colorado has to deliver a certain percent of its runoff every year to the Lobatos gauge at about the Colorado state line. New Mexico's delivery obligation to Texas is defined by the annual flows at the Otowi Bridge. Based on that flow, New Mexico must deliver a certain percentage to Texas.

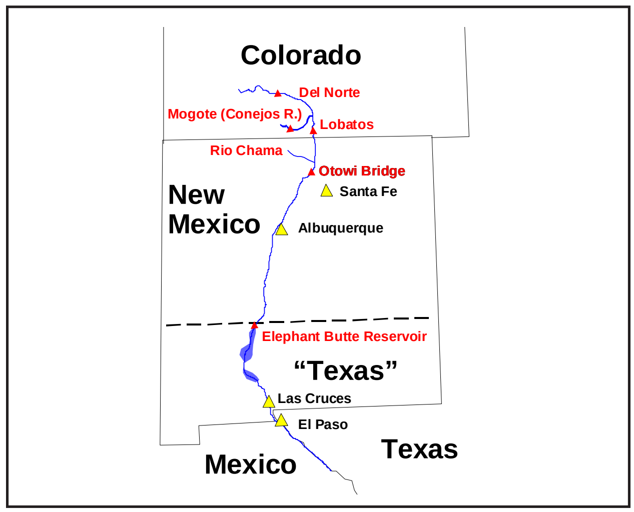

Figure 4. Rio Grande Compact and "Law of the River" divide the water of the Rio Grande

Elephant Butte Lake is where Texas starts for Rio Grande Compact purposes. The Compact mathematically splits up the flows according to how much runoff comes from the mountains. With that in mind, we are interested in the economic impacts of drought.

The approach we took in this study was to identify rules (institutions) for moving water around the system, the most important of which is the Rio Grande Compact. We wanted to estimate the economic damages for selective various drought scenarios under what we call "Law of the River," which means the current rules for sharing shortfalls in drought.

We estimated the economic impact of various ways of coping with this drought by setting up revised rules for moving the water around the system. An important part of the study was to describe the uses, supply, demands, and economic losses produced by various droughts. We did this by building a mathematical model that kept track of the supplies and demands of water as well as total economic benefits produced by the various uses.

The hydrology model kept track of some very simple surface and groundwater interactions. We assembled the model at two levels, including some on site detail and some on a broad regional analysis. For the detailed model, we attempted to replicate the decision processes on irrigated farms for the four major districts in the three states located on the Rio Grande. We also looked at municipal and industrial (M&I) values in benefits associated with water, and we looked at recreational benefits. We did not examine economic values of endangered species.

At the broader regional level, we summed up model results at the detailed farm level as well as accounting for the upstream-downstream interactions.

The next slide (Fig. 5) shows the major characteristics of consumptive uses at various locations in the Basin, starting from Southern Colorado Agricultural down to Albuquerque M&I, down to MRGCD, to EBID, to El Paso, and finally to El Paso Agriculture. The pluses indicated that a particular characteristic is active and a blank means the characteristic is inactive. Thus, this slide summarizes and simplifies what is going on in the Basin.

	Surface Diversion	Ground Water Pumping	Crop Use	M&I Use	Surface Returns	Aquifer Returns
Southern CO Ag	+	+	+	–	+	+
Albuquerque M&I	–	+	–	+	+	–
MRGCD Ag	+	–	+	–	+	+
EBID Ag	+	+	+	–	+	+
El Paso M&I	+	+	–	+	+	+
El Paso Ag	+	–	+	–	+	+

Figure 5. Consumptive uses by location

If we were to look at a normal year, we might see a water budget that looks something like the following slide (Fig. 6). The red lines are the state lines for Colorado/New Mexico, New Mexico/Texas, and Texas/Mexico. On the right-hand side, we have depletions: the numbers are in thousands of acre-feet, which balance as long as New Mexico and Colorado meet their delivery requirements.

Supply		Demand (Depletion)	
Rio Grande Headwaters	660		
Conejos River (3 gages)	346	339	Colorado Ag
Northern NM Mts	139		
Rio Chama	346		
Jemez River	45		
Albuquerque M&I	60	60	Evaporation
Rio Puerco	32	100	Central NM Ag (MRG)
Rio Salado	41	135	Riparian Vegetation
Ungaged tributary inflow		180	Elephant Butte Evap
		495	Southern NM Ag (EBID)
		140	El Paso M&I
		236	Texas Ag
		60	Mexico

Figure 6. Rio Grande Basin Water Budget, normal year

Let's discuss drought scenarios. What if over the next three years the same water inflows to the basin that we've had for the last three years? If we had those inflows for the next three years, what would they look like?

We projected future head-water inflows for the next three years based on head-water flows for the last three years (Fig. 7). Of course, nobody expects exactly the same flows in the next three years as in the last three, but it is a place to begin.

Then based on those inflows, we projected basin-wide sources and uses for the next three years at various places on the river, dividing demands and supplies according to past use patterns and according to the Rio Grande Compact.

- Headwater inflows for 2000-2002
- Reservoir contents for 2000-2002
- 'Project' future headwater inflows for 2003-2005 based on 2000-02 means
- Project basin-wide flows and uses, based on headwater inflows, RG Compact, and minimum reservoir contents for 2005.
  - Chama > 150 K
  - Cochiti > 50 K
  - Elephant Butte + Caballo > 250 K

Figure 7. Drought Scenarios

We built and ran a model that included minimum reservoir contents that are up to 10 percent lower than what we currently have. For example, we assume that the three Rio Chama reservoirs taken together must have no less than 150,000 acre-feet at the end of three years from now. Cochiti Reservoir must have 50,000 acre-feet, about what it had on October 1, 2002. Elephant Butte plus Caballo has to exceed 250,000 acre-feet.

The hydrology model (Fig. 8) is based on water budgets: additions from head-water flows, return flows, and the like.

Hydrology Model

Water budgets

- Additions
  - Headwater inflows (rainfall, snowmelt)
  - Return flows
  - Seepage to aquifer/stream
- Depletions
  - Surface diversions
  - Pumping
  - Reservoir evaporation
- 'Conveyance' functions
  - Unmeasured inflows, outflows
  - Allows water gain, loss from future mgmt

Figure 8. Hydrology Model

The economic sectors we analyzed were agriculture, M&I, and recreation. Detailed farm budgets (Fig. 9) were constructed for Colorado agriculture, based on a Ph.D. dissertation completed at Colorado State University. The M&I analysis (Fig. 10) is based on demand and supply and price elasticities of demand. Recreation (Fig. 11) is based on a reservoir contents and how much recreational use falls off when reservoir contents fall. We analyzed recreation for the six mainstem reservoirs.

Drought-Coping Institutions

One major drought coping institution I'd like to discuss today is adding 5,000 acre-feet of water supply by removing salt cedars north of Socorro.

We found that the drought costs about $127 per acre-foot lost. The Middle Rio Grande Conservancy District (MRGCD) will lose about $19 million per year if this drought continues for the next three years (Fig. 12). EBID loses about $32 million per year, Texas agriculture loses about $13 million, and El Paso water ratepayers lose about $44 million.

Agricultural Analysis

- Based on:
  - NMSU Cost and return budgets
  - Surface and groundwater supply
  - Irrigated acreage
  - Historical cropping patterns
- Developed for: San Luis Valley, CO
- Simplified for: MRGCD, EBID, EP#2
- Used to explain:
  - Adjustment to current/future drought
  - Economic damages from drought
  - Economic benefits from drought-coping institutions

Figure 9. Agricultural Analysis

M&I Analysis

- Based on demand/supply
- Current ground and surface water use
  - Current household use and price
  - Historical household response to price
  - Current and projected population
  - Planned surface water development
- Developed for: Albuquerque and El Paso
- Used to explain
  - Adjustment to drought
  - Economic damages from drought
  - Economic benefits from drought-coping institutions

Figure 10. M&I Analysis

Recreation Analysis

- Based on recreation visitor use
  - Historical use fluctuations with
    - lake level changes
    - on-site facilities
    - population growth
    - demographic factors
    - travel costs
- Developed for 6 major basin reservoirs
- Used to Explain
  - Adjustment to drought (1942-1985 flows)
  - Economic damages from drought
  - Economic benefits from drought-coping institutions

Figure 11. Recreation Analysis

Damages:	By State, Location, User ($1000s/yr)				
Institution:	*Law of the River*				
State	NM		TX		
User	MRGCD Ag	Alb M&I	EBID Ag	EP M&I	EP Ag
	18,900	0	32,000	44,000	13,000
$/AF lost	127				

Figure 12. Annual Average Drought Damages: 0.81 v. 1.57 maf inflow/yr

If we could reduce evaporation at Elephant Butte Reservoir by 25,000 acre-feet per year, New Mexico's MRGCD agriculture saves about $9 million in damages because it can deplete that much more water (Fig. 13). Texas receives no direct benefit from this scenario under the current Rio Grande Compact.

Damages Saved: By State, Location, User ($1000s for yrs 2000-05)					
Institution:	- 25 KAF evap/yr, Elephant Butte Reservoir				
State	NM		TX		
User	MRGCD Ag	Alb M&I	EBID Ag	EP M&I	EP Ag
	9,000	0	0	0	0
$ / AF	$60				

Figure 13. Drought Damages Saved Compared to Law of the River (25,000 ac-ft evaporation reduction at Elephant Butte Reservoir)

If we could produce 5,000 more acre-feet of water by reduced evaporation or other measures that add water back into the three mainstem Chama reservoirs, New Mexico gains about $301,000 per year, while Texas gains about $329,000 per year, for an overall average of about $33 per acre-foot of added water (Fig. 14).

Damages Saved:By State, Location, User ($1000s for yrs 2000-05)					
Institution:	- 5 KAF evap/yr, Chama Reservoirs				
State	NM		TX		
User	MRGCD Ag	Alb M&I	EBID Ag	EP M&I	EP Ag
	301	0	382	0	329
$ / AF	$33				

Figure 14. Drought Damages Saved Compared to Law of the River (5,000 ac-ft evaporation reduction at Chama reservoirs)

If we could produce 20,000 acre-feet more water at the San Acacia gauge through salt cedar control, MRGCD gets about $6.4 million per year in reduced losses. Because of the Rio Grande Compact, Texas receives no direct benefit (Fig. 15).

If we could reduce evaporation by 5,000 acre-feet per year at Cochiti Reservoir, MRGCD gains $1.7 million per year in reduced drought damages, or about $59 per acre-foot of new water (Fig. 16).

If we could produce 20,000 acre-feet more flow at the San Marcial gauge per year through salt cedar control, MRGCD agriculture saves drought damages of about $7 million or about $58 per acre-foot (Fig. 17).

Damages Saved: By State, Location, User ($1000s for yrs 2000-05)					
Institution:	+20 KAF/yr at San Acacia gage (salt cedar)				
State	NM		TX		
User	MRGCD Ag	Alb M&I	EBID Ag	EP M&I	EP Ag
	6,400	0	0	0	0
$ / AF	$52				

Figure 15. Drought Damages Saved Compared to Law of the River (adding 20,000 ac-ft at San Acacia)

Damages Saved:By State, Location, User ($1000s for yrs 2000-05)					
Institution:	- 5 KAF evap/yr, Cochiti Reservoir				
State	NM		TX		
User	MRGCD Ag	Alb M&I	EBID Ag	EP M&I	EP Ag
	1,709	0	0	0	0
$ / AF	$59				

Figure 16. Drought Damages Saved Compared to Law of the River (5,000 ac-ft evaporation reduction at Cochiti Reservoir)

Damages Saved: By State, Location, User ($1000s for yrs 2000-05)					
Institution:	+20 KAF/yr at San Marcial (salt cedar)				
State	NM		TX		
User	MRGCD Ag	Alb M&I	EBID Ag	EP M&I	EP Ag
	7,000	0	0	0	0
$ / AF	$58				

Figure 17. Drought Damages Saved Compared to Law of the River (adding 20,000 ac-ft at San Marcial)

For more details, we have a report on the NMWRRI's web page at: http://wrri.nmsu.edu/publish/techrpt/tr317/downl.html.

Conclusions

Models are a nice way to organize information. They help you identify knowledge gaps. They can be expensive to build, but they are usually cheap to run and tell you something about effects of a wide range of possible policies. One of the limits of the current drought study model is that its groundwater-surface water interaction is still weak, so policy analyses that rely on that interaction will be incomplete.

The current Law of the River is a widely understood and accepted institution for dividing the waters of the Rio Grande. In particular, the Rio Grande Compact provides structure as well as possessing good drought-coping flexibility. If the Compact were augmented with measures like water leasing and water banking, it may be an economically effective way to reduce drought damages.

Here are a few future researchable questions with major policy implications: What are the impacts of changing system operation? What is the economic cost of protecting endangered species and how can those costs be minimized while being compatible with the species' needs? What is the sensitivity of our modeled results to changes in the assumptions?