

# FORUM

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# Rime of the Ancient Mariner

**D**uring the sixth century, Teotihuacan, in the Valley of Mexico, was the sixth largest city in the world. With a population of a quarter of a million in an area a third the size of Manhattan, Teotihuacan was the most advanced civilization in the Americas before the Europeans arrived a thousand years later.

We don't know for sure who laid out the city or even when it began, but we do know it flourished for at least 500 years. Teotihuacan was an intricately planned city, designed according to astrological principles, with apartments, artisans' studios, markets, temples, and 600 pyramids. The Pyramid of the Sun is reputedly the third largest in the world.

Teotihuacan collapsed during the sixth century when a 30-year drought dried up fields of maize, squash, and beans, forcing the people to either move on or starve. When Cortez passed through the Valley of Mexico in the 16th century, the ancient city had long since been abandoned. The overgrown and unrecognizable Pyramid of the Sun was just one more hill in the way of his cortege, which was on its way to crushing the Aztecs near the site of modern day Mexico City, 30 miles to the southwest.

Water—either its scarcity, its excess, or its noxiousness—has been the downfall of many a civilization throughout history. Even the early culture at Mesopotamia, the cradle of agriculture, collapsed after poisoning its soils with irrigation salts. Shortly after seeding the agricultural revolution, Mesopotamia was no longer fit for farming. A similar story is being retold today in California's San Joaquin Valley. The farmers of this rich agricultural region have tried everything from underground drainage tiles to drip-irrigation techniques to desalinization to salt-tolerant crops—so far, with little real success.

It takes a thousand pounds of water to produce one pound of grain. One pound of grain can sustain the average person for a single day. That thousand pounds of water, however, is increasingly hard to come by. Water is rapidly becoming the next great resource crisis, and FORUM is devoting this entire issue to the topic.

Ironically, Earth—a misnomer—is a water planet, and yet through overuse and misuse, we don't have enough usable water to accommodate projected growth into the foreseeable future. Unlike the people of Teotihuacan who, despite incredible ingenuity, were overwhelmed by water shortages, we do have solutions. Putting those solutions to work, however, will require time and technology and political will. We can't afford our story to trail off the way the Ancient Mariner's did with "Water, water everywhere, Nor any drop to drink."

Dennis Mc Carthy

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# Global Drain

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## Running on Empty

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# High and Dry

**O**n every continent, water tables are falling, wells are running dry, and drought threatens the livelihood of farmers. Water shortages will only increase with the rise in global population, and shortages will intensify as rural residents migrate to urban areas, where water usage is typically three times greater than in the country. When demand for water outstrips supply, conflict is inevitable.

The term *water wars* conjures the image of a standoff between livestock owners in the American West, but in the future, water wars may instead be fought over grain. When farmers in one country export irrigated crops such as wheat, they are in fact exporting their most precious, and nonrenewable, resource. “The water required to produce the grain and other foodstuffs imported into North Africa and the Middle East last year was roughly equal to the annual flow of the Nile River,” says Worldwatch Institute President Lester Brown.

The deficit is in part due to new technologies of the last 50 years that allow us to pump huge amounts of water from the aquifer, initially for irrigation. As populations increase and urbanization creates new demand, water is diverted from irrigation, resulting in food production capacity losses and the need

to import grain and other foodstuffs. Severe water shortages almost inevitably follow. We cannot prevent catastrophic deficits that could lead to famine and international strife unless we raise water productivity by eliminating inefficient water subsidies, raising the price of water to reflect its cost, and shifting to new and more-efficient technologies, crops, and forms of animal protein, Brown says.

Along the Mexican-Texas border, recent droughts have uncovered the inadequacies of old treaties to deal with fair allocation of the waters of the Rio Grande—known in Mexico as the Rio Bravo—as well as the aquifer, which is being depleted. Increased economic development and a growing population have meant that water historically used for irrigation is now being diverted for industrial and municipal uses. The drought of 1998 hit agricultural irrigators particularly hard. David Hurlbut, formerly at the University of Texas, outlines the need for a new treaty to help the region deal with their shared water problems and stave off the threat of water bankruptcy.

Finally, Jefferson Edgens at the University of Kentucky looks at an interstate battle between Georgia, Alabama, and Florida. At issue are two major river systems that have their headwaters in the north Georgia mountains. Although Georgia is one of the wettest states in the nation, the burgeoning de-

mands of metro Atlanta—one of the fastest growing cities in the nation—is rewriting water law in the East.

Atlanta has been siphoning off water that, under traditional eastern water law, should be available for downstream users. As a result, policymakers are looking to legal solutions, such as interbasin water transfers, that are more typical of the water-scarce West.

Although no settlement of the battle is in sight, negotiators are attempting to tie local land-use planning with regional watershed management. Allocations for water use will remain at the local level, but local decisions about such questions as how many new subdivisions and industrial parks can be constructed will have to be coordinated with regional watershed plans. Unfortunately, however, the states have not been able to develop the needed watershed plans.

Edgens believes the ultimate solution lies in developing a market-based system for allocating water. Lack of ownership rights to water translates into greater waste, he says: “A market-based strategy, in which the water that people use is accurately reflected by price, can go a long way toward minimizing water allocation problems.”

*The Editors*



# Running on Empty

*Worldwide population growth is sentencing millions to hydrological poverty.*

BY LESTER R. BROWN

**N**ow that drought in the United States, Ethiopia, and Afghanistan is in the news, it is easy to forget that far more serious water shortages are emerging as the demand for water in many countries simply out-runs the supply. Water tables are now falling on every continent. Literally scores of countries are facing water shortages as water tables fall and wells go dry.

We live in a water-challenged world, one that is becoming more so each year as 80 million additional people stake their claims to the Earth's water resources. Unfortunately, nearly all the projected 3 billion people to be added to the world's population over the next half century will be born in countries that are already experiencing water

shortages. Even now, many in these countries lack enough water to drink, to satisfy hygienic needs, and to produce food.

By 2050, India is projected to add 519 million people and China 211 million. Pakistan's population is projected to more than double, going from 151 million at present to 348 million. Egypt, Iran, and Mexico are slated to increase their populations by more than half. In these and other water-deficient countries, population growth is sentencing millions of people to hydro-

logical poverty, a local form of poverty that is difficult to escape.

Even with today's 6 billion people, the world has a huge water deficit. Using data on over-pumping for China, India, Saudi Arabia, North Africa, and the United States, Sandra Postel, author of *Pillar of Sand: Can the Irrigation Miracle Last?*,<sup>1</sup> calculates the annual depletion of aquifers at 160 billion cubic meters or 160 billion tons. Using the rule of thumb that it takes 1,000 tons of water to produce one ton of grain,

this 160-billion-ton water deficit is equal to 160 million tons of grain or one-half the annual U.S. grain harvest.

With an average world grain consumption of just over 300 kilograms or one-third of a ton per person per year, this would feed 480 million people. In other words, 480 million of the world's 6 billion people are being fed with grain produced with the unsustainable use of water.

## **Rising Demand**

**O**verpumping is a new phenomenon largely confined to the last half century. Only since the development of powerful diesel and electrically driven pumps have we had the capacity to pull water out of aquifers faster than it is replaced by precipitation.

Some 70 percent of the water consumed worldwide—including what is diverted from rivers and pumped from underground—is used for irrigation, some 20 per-

cent for industry, and 10 percent for residential purposes. However, as competition for water among sectors becomes increasingly intense, agriculture almost always loses. The 1,000 tons of water used in India to produce 1 ton of wheat worth perhaps \$200 could instead be used to expand industrial output easily by 50 times as much, or \$10,000. This ratio helps explain why, in the American West, the sale of irrigation water rights by farmers to cities is an almost daily occurrence. (See "Western Groundwater Wars" in this issue of FORUM.)

Urbanization and industrialization also expand the demand for water. In developing countries, as villagers who traditionally rely on the village well move to urban high-rise apartment buildings with indoor plumbing, their residential water use can easily triple. Industrialization takes even more water than urbanization.

Rising affluence in itself generates additional demand for water. As people move up the food chain—consuming more beef, pork, poultry, eggs, and dairy products—they use more grain. A U.S. diet rich in livestock products requires 800 kilograms of grain per person a year, whereas diets in India, dominated by a starchy food staple such as rice, typically need only 200 kilograms. Using four times as much grain per person means using four times as much water.

### **Importing Water**

Once a localized phenomenon, water scarcity is now crossing national borders via the international grain trade. The world's fastest growing grain im-

port market is North Africa and the Middle East, an area that includes Morocco, Algeria, Tunisia, Libya, Egypt, and Iran. Virtually every country in this region is simultaneously experiencing water shortages and rapid population growth.

As the demand for water in the region's cities and industries increases, it is typically satisfied by

be fought over water than oil. Perhaps, but given the difficulty in winning a water war, the competition for water seems more likely to take place in world grain markets. The countries that will win in this competition will be those that are financially strongest, not those that are militarily strongest.

The world water deficit grows larger each year, making it increas-

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## **As competition for water among sectors becomes**

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### **increasingly intense, agriculture almost always**

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**loses.**

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diverting water from irrigation. The loss in food production capacity is then offset by importing grain from abroad. Since one ton of grain represents 1,000 tons of water, this becomes the most efficient way to import water.

Last year, Iran imported 7 million tons of wheat, eclipsing Japan to become the world's leading wheat importer. This year, Egypt is also projected to move ahead of Japan. Iran and Egypt have nearly 70 million people each, and their populations are increasing by more than a million a year, pushing the limits of their water supplies.

The water required to produce the grain and other foodstuffs imported into North Africa and the Middle East last year was roughly equal to the annual flow of the Nile River. That is, the fast-growing water deficit of this region is equal to another Nile flowing into the region in the form of imported grain.

It is now often said that future wars in the region will more likely

be fought over water than oil. Perhaps, but given the difficulty in winning a water war, the competition for water seems more likely to take place in world grain markets. The countries that will win in this competition will be those that are financially strongest, not those that are militarily strongest. The world water deficit grows larger each year, making it increasingly more difficult to manage. If we decided abruptly to stabilize water tables everywhere by simply pumping less water, the world grain harvest would fall by some 160 million tons, or 8 percent, and grain prices would go off the top of the chart. If the deficit continues to widen, the eventual adjustment will be even greater.

### **Stabilizing Population**

Unless governments in water-short countries act quickly to stabilize population and to raise water productivity, their water shortages may soon become food shortages. The risk is that water-short countries, including population giants China and India, with rising grain import needs, will overwhelm the exportable supply in countries with food surpluses such as the United States, Canada, and Australia. This, in turn, could destabilize world grain markets.

Another risk of delay in dealing with the deficit is that some low-

income, water-short countries will not be able to afford to import needed grain, trapping millions of their people in hydrological poverty and leaving them thirsty and hungry, unable to escape.

Although there are still some opportunities for developing new water resources, restoring the balance between water use and the sustainable supply will depend primarily on demand-side initiatives such as stabilizing population.

Governments can no longer

separate population policy from the supply of water. Just as the world turned to raising land productivity a half century ago when the frontiers of agricultural settlement disappeared, so it must now turn to raising water productivity. The first step toward this goal is to eliminate the water subsidies that foster inefficiency. The second step is to raise the price of water to reflect its cost. Shifting to more water-efficient technologies, crops, and forms of animal protein offers a huge potential for raising water

productivity. These shifts will move faster if the price of water more closely reflects its value. ■

*Lester Brown is president of the Worldwatch Institute, Washington, D.C.*

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#### NOTES

1. Sandra Postel, *Pillar of Sand: Can the Irrigation Miracle Last?* (New York, NY: W.W. Norton & Company, 1999).



# The Good, the Bad, and the Arid

*Do the United States and Mexico need a new treaty to help them better manage the Rio Grande?*

**BY DAVID HURLBUT**

**N**obody needs to tell residents of southern Texas and northern Mexico that the last five years have been dry. They already know it's worse than even the so-called drought of record nearly half a century ago. The 1950s were just as dry, but back then there were only a third as many people in the region as there are today.<sup>1</sup> The economies of Texas and Mexico have become more integrated, and on both sides of the border urban infrastructure—especially for drinking water and sewage treatment—has often failed to keep up with industrial development and population growth.

Texas's most-populous border counties have been among the state's fastest-growing areas. Mexico's three most-populous northern states are growing faster than the Mexican national rate.<sup>2</sup> Juarez, across from El Paso, and Nuevo Laredo, across from Laredo, today are two of Mexico's most important employment centers. The additional municipal and industrial demand for water have come on top of the historical demand for irrigation near El Paso and Juarez, forcing farmers on both sides of the border to compete for water with economically stronger rivals.

Much has changed since the last drought. Two things that have not,

however, are the treaties that govern how much water each country gets.

Behind today's crisis of supply and demand lies a crisis of planning. On both sides of the river—known in the United States as the Rio Grande and in Mexico as the Río Bravo—water planning has traditionally been conducted with one hand tied behind the back. Neither side knew what was happening on the other—either in terms of water supplies or projected demand.

The political battle in the United States over the North American Free Trade Agreement in 1992, however, helped draw back the information curtain separating water planners in Texas and northern Mexico. New institutions were created to address natural resource and environmental issues along the border. In addition, state and national agencies concerned with water resources—aided by improved technology such as remote sensing and geographic information systems—have increased informational exchanges with their counterparts across the river.

Economic integration, technological advance, and a spirit of cooperation notwithstanding, the two governing international agreements—one of them almost a century old—constrain what can be done to address the current water crisis and avoid future ones. Experts have proposed alternative treaty models designed to help, rather than hinder, binational water planning.<sup>3</sup> Those ideas went nowhere when they were first mooted, but now that the recent drought has shown the day of hydrological reckoning to be clearer and nearer, perhaps it's time for the United States and Mexico to

consider negotiating a new water treaty better suited to addressing the problem as it exists today.

### One River, Two Treaties

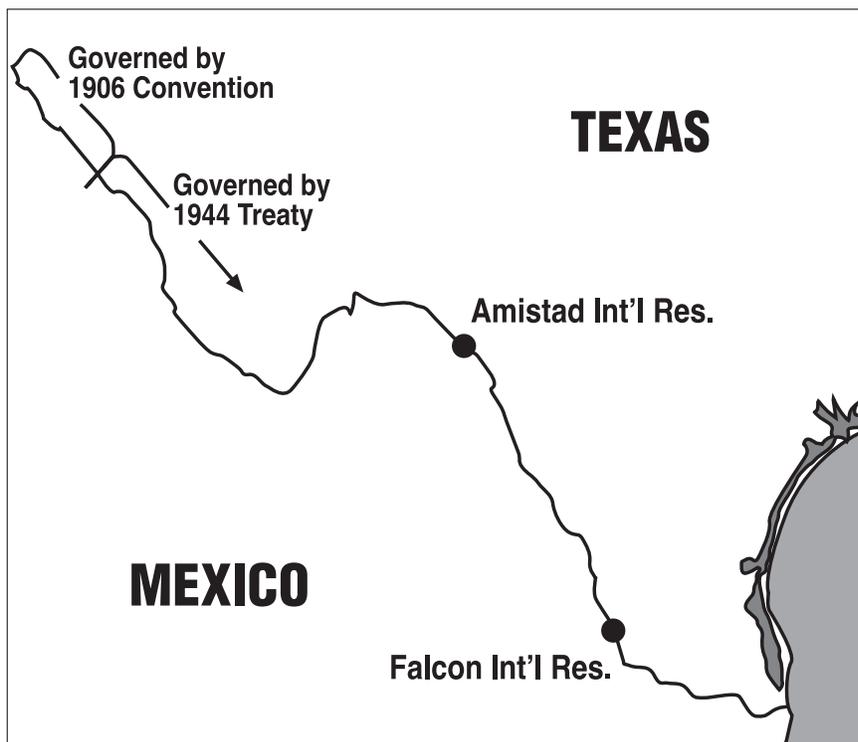
The stretch of the Rio Grande that separates the United States and Mexico comprises two segments that differ both legally and hydrologically. The sister cities of El Paso, Texas, and Ciudad Juarez, Chihuahua, constitute the economic hub of the upper segment. In this area, a 1906 agreement governs how much of the river the United States must deliver to Mexico each month; Texas gets the rest.

Immediately below El Paso/Juarez, the stream flow virtually disappears during all but the wettest years. Eventually, upstream from Amistad International Reservoir, the Rio Grande is created anew by such rivers as the Río Conchos from Mexico and the Pecos River from the United States. From Amistad International Dam and Reservoir to the Gulf of Mexico, the river is controlled, its channel essentially a conveyance for water stored in Amistad and Falcon International Reservoirs. Ownership of the water in this segment of the river is determined by a detailed water-accounting regime established by treaty in 1944.

### The Good: The 1944 Treaty

The treaty of 1944 accomplished several things. First, it called for the construction of three international dams and reservoirs along the Rio Grande/Río Bravo.<sup>4</sup> Second, it created the International Boundary and Water Commission (IBWC) and charged it with setting the location of the dams and reservoirs, overseeing their con-

Figure 1: The Rio Grande and its international reservoirs.



struction, and operating them for the benefit of both countries.

Third, the treaty apportioned the water in the 14 major tributaries that flow from Texas and Mexico into the Rio Grande/Río Bravo. Water from two Mexican tributaries is entirely Mexico's. Water from the six U.S. tributaries belongs entirely to the United States. Water from the other six Mexican tributaries is allocated between the two countries, two-to-one in favor of Mexico.

All other inflows are divided equally, as is the channel flow from the last downstream reservoir, Falcon Reservoir, which has been released specifically for the use of either country.<sup>5</sup> Finally, the treaty stipulates that during periods of low flow, the United States shall get at least 350,000 acre-feet (432 million cubic meters) per year from the six shared Mexican tribu-

taries. To make compliance feasible, the flows are averaged over a five-year period so that a shortfall in one year can be made up the next. The treaty worked reasonably well until the 1990s.

In 1995, drought hit northern Mexico hard. Many municipalities in the state of Chihuahua faced severe water shortages. In response, Texas agreed to loan Chihuahua 81,000 acre-feet of water to be taken from the U.S. share of the Conchos River flowing into the Rio Grande/Río Bravo from Mexico.<sup>6</sup> The IBWC implemented this historic agreement, as provided by the 1944 treaty. Although Mexico didn't draw on this hydrological line of credit, the agreement established a precedent for cooperation and quick response during a time of crisis.

A more serious problem was developing, however. From Novem-

ber 1992 to October 1997, Mexico fell short by some 1 million acre-feet of the 350,000 acre-feet per year it is obligated to provide Texas.<sup>7</sup> Because the latter part of this period coincided with the beginning of the drought, reservoirs in Mexico fell to critically low levels, and flows in the six tributaries that were to be shared fell far below what was necessary to deliver on Mexico's obligation.

In Texas, the water deficit hit the agricultural sector especially hard. The U.S. share of water in the international reservoirs is allocated to farmers only after all municipal water rights are secured.<sup>8</sup> Consequently, any reduction of inflows to the United States comes at the expense of Texas irrigators. The most serious effects occurred in 1998, when a number of major irrigation districts in Hidalgo and Cameron Counties ran out of water near the end of the peak irrigation cycle.

Mexico has been working to make good on the water deficit, and during the first half of 2000, it transferred 135,000 acre-feet to the United States.<sup>9</sup> That volume—equivalent to 13 percent of the accumulated deficit—was part of Mexico's share of water stored in Falcon and Amistad Reservoirs and was transferred early enough to provide additional peak-season irrigation to Texas farmers. The effect on Mexican farmers has yet to be tallied, however. The transfer exacerbated a sharp decline in the amount of water Mexico had in the two reservoirs, and by June 2000, the country's combined storage was under 220,000 acre-feet, less than 9 percent of its storage capacity.<sup>10</sup> Mexico's water in storage was still around that same level as of February 2001, compared with

43 percent for the United States.

To ensure that the same problem does not arise during the 1997-2002 period, the IBWC assigned to the United States a larger proportion of the water flowing into the Rio Grande/Río Bravo from Mexican tributaries for most of 2000. The goal was to deliver 400,000 acre-feet for the year, enough to satisfy the requirement of the treaty and to hedge against further water deficits.

### **The Bad: The 1906 Treaty**

Compared with the detailed treaty of 1944, the 1906 Convention for the Equitable Distribution of the Waters of the Rio Grande at El Paso and Ciudad Juarez is concise and simple. It grants Mexico 60,000 acre-feet of water per year except during drought, keeps the rest for Texas, and establishes absolute U.S. sovereignty over the upper Rio Grande, before the river becomes the international boundary.<sup>11</sup>

The 1906 agreement is most notable, however, for what it does *not* do. The century-old treaty says nothing at all about the aquifer system lying beneath El Paso and Juarez, which provides both cities with most of their domestic water. Nor does it provide any legal authority for officials from Juarez and El Paso, or from Chihuahua and Texas, to respond jointly to water crises that affect both sides. Consequently, the agreement is rather inflexible—the institutional boulder around which all other efforts must flow.

Historically, El Paso has relied on groundwater for most of its municipal supplies. As its population has grown and aquifer levels have fallen, however, the city has had to purchase a larger por-

tion of its water supply from the agricultural sector's main supplier of irrigation, El Paso County Water Irrigation District, whose members hold rights to the largest share of the surface water not given to Mexico. Purchased surface water from the Rio Grande/Río Bravo now constitutes more than 40 percent of the city's municipal water supplies, compared with 20 percent in the early 1980s.<sup>12</sup> And even though the city has been rather successful with water-conservation measures, reducing municipal consumption from approximately 200 gallons (760 liters) per capita per day in the late 1980s to fewer than 170 gallons (640 liters) in the late 1990s, population growth has outstripped its conservation efforts. Consequently, total municipal water use has grown from under 117,000 acre-feet in 1990 to more than 127,000 acre-feet in 1997.<sup>13</sup>

Groundwater is being used up much faster than it can be replenished. El Paso takes a considerable amount of water from the aquifer system—73,000 acre-feet in 1997—while on the Mexican side, authorities estimated a total annual extraction of 250,000 acre-feet in 1995.

Officials in Texas and Mexico differ widely in their estimates of the aquifer's annual recharge. The Texas Water Development Board estimates that 24,000 acre-feet of water replenish the aquifer each year. Mexico's Comisión Nacional del Agua, on the other hand, estimates the recharge to be 235,000 acre-feet.

Whatever the actual number, more is being pumped out than is going back in. And while the amount of freshwater stored in the aquifer is also unknown, the U.S.

Geological Survey concludes that, without effective management, the aquifer could be depleted in this century.

To complicate matters, the largest source of recharge for the aquifer is the Rio Grande/Río Bravo itself. Thus, farmers and city-dwellers on both sides continue to draw down the aquifer *and* use up the surface water that would otherwise help recharge it. Neither side has much choice. Both are caught in a dilemma of the commons; potential solutions exist, but they require cooperation, a measure of short-term abstinence and investment, and trust that the other side will carry its share of the burden. Without an institutional framework that puts both sides on equal footing and provides credible measures for joint monitoring and enforcement, the only alternative for either is to continue pumping.

### **Dealing with the Arid**

While not perfect, the 1944 treaty has set important precedents for binational management of a shared river. The foremost lesson is the value of ongoing diplomatic exchange. When supply issues became complicated, the IBWC provided a forum for discussing problems and exploring options. Mexico may not be eliminating its water deficit as quickly as farmers in Texas's Lower Rio Grande Valley would like, but resolution would, in all likelihood, be much slower in coming had the U.S. State Department been the only place Texas farmers could take their grievances.

Second, hydrological intelligence has been a key part of the IBWC's role. The detailed information it gathers on water flows

and storage form the basis of domestic surface-water management in the region. Little time was spent arguing over how much water Mexico owed the United States, leaving officials a clearer table to discuss options.

Third, the principle governing water allocation under the 1944 treaty is equitable apportionment of the amount of water the IBWC determines is available. Neither party has a priority interest.

Finally, and perhaps most significantly, the construction of dams and reservoirs ensured that more water would be available to apportion.

In stark contrast, the 1906 convention is doing nothing to help El Paso and Juarez deal with their shared water problems and forestall the threat of water bankruptcy. A new treaty—modeled after the 1944 agreement—for El Paso/Juarez is in order. The treaty should:

- Define the hydrological area comprising the Rio Grande/Río Bravo and the aquifer system underlying El Paso and Juarez, declaring it an international hydrological zone.

- Expand the IBWC's authority to include the El Paso/Juarez international hydrological zone.

- Give to the IBWC the task of deducing aquifer recharge on a regular basis.

- Apportion the deduced aquifer recharge between the United States and Mexico, crediting to each country the recharge occurring on its territory and dividing, on a pro rata basis, the recharge occurring from the stream bed of the Rio Grande/Río Bravo.

- Apportion surface water of the Rio Grande/Río Bravo between the United States and Mexico on a pro

rata basis. This measure would supercede the 1906 convention.

- Establish a procedure to set aggregate groundwater withdrawal ceilings for each country, based on the volume of deduced recharge it owns.

- Give the IBWC authority to limit total groundwater withdrawals to less than the recharge rate if the aquifer is in danger of permanent damage.

- Give to the IBWC the task of monitoring groundwater withdrawals from all wells in the international hydrological zone.

- Establish a procedure by which each country may exchange some of its surface-water credit for some of its groundwater credit; that is, either side would be allowed to use more groundwater if it used less surface water, and vice versa.

- Provide for the construction of facilities to enhance aquifer recharge and meter all wells.

A treaty based on this model would not preclude the acquisition of water supplies from outside the hydrological region. For example, El Paso has purchased raw land in other parts of west Texas to acquire the rights to the underlying groundwater. If these aquifers are outside the international hydrological zone and water from them is piped to the city, El Paso's groundwater balance with the expanded IBWC would be unaffected. In fact, as this treaty is proposed, El Paso could even receive credit for any return flows that are pumped into the international aquifer.

The principles underlying this proposal are squarely at odds with Texas water law. Texas holds to the common-law rule of capture, in which groundwater is generally held to be the private property of whoever owns the land above it.

Nevertheless, the U.S. Constitution clearly establishes that an international treaty ratified by the Senate overrides any state law.<sup>14</sup>

Moreover, both the Texas legislature and the Texas Supreme Court have tacitly recognized that the rule of capture is untenable in areas where aquifers are the main source of water.<sup>15</sup> Thus, if the United States and Mexico both deem it in the public interest to create by treaty a special international hydrological zone around El Paso and Juarez, to be managed bilaterally, Texas's rule of capture would be rendered inapplicable in the zone defined by the treaty.

Changing treaties is an ambitious undertaking, however. Even though it is the hydrological debtor in the current crisis, the Mexican government has shown little interest in modifying the 1944 agreement. This is understandable; reopening the treaty threatens the status quo, raises uncertainty, and risks creating more problems than solutions. Still, as El Paso and Juarez move ever closer to hydrological bankruptcy, the risk of change may become less frightening than the risk of keeping things the same. ■

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## NOTES

1. U.S. Bureau of the Census, "Population of Counties by Decennial Census, 1900 to 1990" (Washington, DC, 1994); U.S. Census Bureau, "County Population Estimates for July 1, 1999 and Population Change: April 1, 1990 to July 1, 1999" <<http://www.census.gov/population/www/estimates/countypop.html>>.

2. Instituto Nacional de Estadística, Geografía e Informática, "Encuesta Nacional de la Dinámica Demográfica" (Mexico City, Mexico, 1997).

3. See, for example, Robert Hayton and Al Utton, "Transboundary Groundwaters: The Bellagio Draft Treaty," *Natural Resources Journal* 29 (1989), pp. 663-722.

4. Falcon Dam was completed in 1953; Amistad Dam was completed in 1969. The treaty also provides for a third dam and reservoir at a site to be recommended by the International Boundary and Water Commission and approved by the governments of Mexico and the United States.

5. Utilization of Waters Treaty of the Colorado and Tijuana Rivers and of the Rio Grande, Treaty between the United States of America and Mexico, 1944 Treaty, Article 4 <<http://www.ibwc.state.gov/FORAFFAI/1944.HTM>>.

6. International Boundary and Water Commission, Minutes No. 293 (El Paso, Texas, October 4, 1995).

7. John M. Bernal, Commissioner of the U.S. Section of the International Boundary and Water Commission, news release (El Paso, Texas, May 4, 2000). One acre-foot equals 1,233 cubic meters or 325,500 gallons.

8. Under the water-accounting procedures used by Texas water officials along the lower and middle Rio Grande, a certain amount of the U.S. allocation is always set aside to ensure municipal water rights are completely satisfied. Each month, new reservoir inflows are

used to replenish the reserves, and the residual is then allocated among holders of irrigation rights. See Texas Administrative Code, Title 30, Chapter 303, subchapter C.

9. Bernal, press release (May 4, 2000).

10. IBWC, current storage conditions (June 2000).

11. Since 1980, deliveries to Mexico have met treaty obligations. Nonetheless, the 60,000 acre-feet allotted to Mexico, which may have been sufficient in 1906, is far below irrigation demand. The 53,000 acres of Mexico's Juarez Valley Irrigation District use the 60,000 acre-feet Mexico receives under the 1906 agreement, about 88,000 acre-feet per year of groundwater, and another nearly 38,000 acre-feet of *aguas negras* (wastewater) from Juarez. Comisión Nacional del Agua, "Programa Hidráulico de Gran Vision del Estado de Chihuahua 1996-2020" (Mexico City, June 1997).

12. Texas Water Development Board, "Water Use by Municipal User for 1980-1996" <<http://www.twdb.state.tx.us/data/wiic/wiic-data.htm>> (Austin, Texas, April 27, 1999).

13. *Ibid.*

14. Article VI, clause 2. An important U.S. Supreme Court decision, *Sporhase v. Nebraska ex rel. Douglas*, 458 U.S. 941 (1982), also affirms groundwater's value as an article of commerce, thus making it subject to the Constitution's interstate commerce clause despite any state law to the contrary.

15. In recent years, the Texas legislature has expanded the powers of groundwater conservation districts, although it has stopped short of striking down the rule of capture completely. The state supreme court upheld the legislature's approach in 1999, but at the same time noted the inequities caused by the rule of capture. *Sipriano v. Great Springs Waters of America, Inc.*, 1 S.W.3d 75 (Texas, 1999).

16. This article was written while the author was at the Lyndon B. Johnson School of Public Affairs, the University of Texas.



# Thirst for Growth

*In southeastern water wars, Georgia holds the trump card: the headwaters of two major river basins that cross state lines.*

BY JEFFERSON G. EDGENS

While skirmishes over the allocation of scarce water resources have been common in the more-arid western states, such as California, Colorado, and Nevada, rapid population growth has brought the prospect of water wars to the water-rich Southeast. For more than a decade, the states of Alabama, Georgia, and Florida have been engaged in a dispute over water resources. One of the wettest states in the region, Georgia, has two major river basins with headwaters in the north Georgia mountains. This puts Georgia at the center of the tri-state dispute. All streamflow in these two basins moves in a mostly southwesterly direction across Georgia—and through the metro-Atlanta region—before entering Alabama or Florida. In

the future, managing water supply to account for Atlanta's growth as well as fulfill the needs of downstream states will be a tall order.

The two river basins at the center of this tri-state water war are the Apalachicola, Chattahoochee, and Flint (ACF), and the Alabama, Coosa, and Talapoosa (ACT). The ACT river basin flows from Georgia through Alabama and empties into the Gulf of Mexico at Mobile Bay, while the ACF river basin crosses into portions of Florida and empties into the Gulf at Apalachicola Bay.

Both bays are essential for maritime commerce; Apalachicola Bay, in fact, is one of the richest oysters beds in the nation. If adequate flow for Mobile Bay or Apalachicola Bay is not maintained, water levels will deteriorate and water quality will decline. For Apalachicola Bay, this is a significant concern be-

cause most oyster beds need fresh water or bay flushing to be productive.

In addition, Florida and Alabama, like Georgia, are also growing. The central issue in this tri-state dispute is how to allocate water resources from these two river basins in a way that allows further growth in the metropolitan Atlanta region without compromising water quantity and quality for downstream users in Georgia and its Alabama and Florida neighbors.

While negotiations have been contentious, the debate has generated new ideas. One of the more promising concepts to emerge is linking watershed plans to comprehensive, local land-use plans. This ensures local control of water allocation. Comprehensive watershed planning also requires coordinating decisions about how many new homes, commercial sites, and industrial parks are to be constructed and where they can be constructed. In essence, watershed management requires a regional approach to dealing with water quantity and water quality, since watershed boundaries ignore political jurisdictions.

Watersheds, of course, encompass several counties or states, yet our land-use planning remains completely at the hands of county government. This raises additional questions for regional planning and watershed management, specifically, what can be done about local sovereignty. Depending on the shape of a tri-state agreement, local sovereignty will either be eroded or left much as it is. Where the tri-state pact would infringe on local control is combining water-quantity and land-use restrictions from a top-down structure. One real possibility is fash-

ioning an agreement that ties new water withdrawals with a land-use plan while giving regional governance veto power, thus effectively overriding local decisions.

An assessment of what is taking place in the tri-state area may serve as a lesson for planners in other regional watershed disputes.

### **Legal Nuances**

Water law has a long history, especially in the western United States. (See “Western Groundwater Wars” in this issue of FORUM.) There are two distinct water regimes within the nation: prior appropriation and riparian rights.

Under the doctrine of prior appropriation, the landowner who has the first claim on the land also has first rights for nearby water resources. These waters do not have to be adjacent to the land, but could in fact be hundreds of yards or several miles away. All landowners have to do to lay claim to the water resource is to put the water to use. They then essentially have legal title to that resource and can divert the water to their own property, or sell it to anyone, even outside the water basin or the state.

Riparian rights, on the other hand, prevail in the eastern United States. In riparian rights regimes, landowners have the right to use water that runs through or lies adjacent to their property.

These two legal concepts—prior appropriation and riparian rights—combine to ensure that water law doctrine will evolve over time, and the law in Georgia is no exception. For example, interbasin water transfers are familiar concepts in the water-scarce western United States, but they are foreign in many respects to the wetter east-

ern United States. Yet the three states with an interest in the water of Georgia’s two water basins are proposing interbasin transfers as a primary method of settling their water disputes. This places Georgia, Florida, and Alabama in the same league as the western states in using the doctrine of prior appropriation in a region that usually respects riparian rights.

### **Sharing the Wealth**

The future growth of metro Atlanta is a major factor in the dispute over water allocation in the region. Downstream users also want their share of these two river basins, and much of that area is either agricultural land or is rapidly urbanizing. South Georgia, for example, is mostly agricultural, and relies in part on irrigation to sustain its farming economy. The cities of Birmingham and Montgomery, Alabama, which continue to grow, also rely on water from these two water basins. Somehow, Atlanta and Georgia must share their bountiful water resources with Alabama and Florida.

Georgia can control the water resources within the state for several reasons. One, the headwaters of both river basins originate in north Georgia and the north Georgia mountains. Most water diversions were created either to ensure an ample supply of water or to control flooding. In essence, Georgia is hoarding the water from the downstream states for its own purposes. How to balance these and other competing uses for agriculture, the environment, and urbanization becomes a critical question.

Some would even argue that any agreement the three states create will limit growth within Georgia.

Opponents of the tri-state water plan, for example, claim that Alabama and Florida indeed want the water, but they further charge that environmental groups also want to limit growth—and economic development—by imposing land-use planning in metropolitan Atlanta and the rest of Georgia as well. Whether or not these claims are true, the three states need to minimize conflict in managing their water resources and providing for the future needs of the three states’ populations.

### **Rome: Ground Zero**

Rome, Georgia, is at the center of the controversy between the state and its western neighbor, Alabama. Rome lies in the northwest portion of the state at the confluence of the Etowah and Oostanaula Rivers, which form the Coosa River. The Coosa flows 320 miles diagonally across the state of Georgia through Alabama and empties into Mobile Bay.

The Coosa has the largest diversity of freshwater snails in the world and is valued as habitat for a variety of endangered species. In addition, like most rivers, the Coosa was a major component of early transportation and a cog in the wheel of economic development in northwest Georgia and Rome in particular. Rome, however, not only received the benefits, it also absorbed the costs associated with the confluence.

Early in Rome’s history, paddle boats plied the river, loading cotton at Rome and delivering it to port in Greensport, Alabama. Return trips brought passengers and goods to the town. During times of floods, though, Rome found itself under water, as the Coosa would overflow its banks and flood

downtown. To correct the problem, at first downtown streets were raised to the second floor of most stores. In the 1930s, the U.S. Army Corps of Engineers constructed levees at downtown Rome on both sides of the Oostanaula. The Etowah was controlled by a dam that created Lake Allatoona, north of Atlanta. Conceived in the late 1940s as an answer to Rome's flooding problem, Lake Allatoona also serves as one of many reservoirs that supply drinking water to a growing metro Atlanta region.

Also competing for the use of the Coosa's water are major industries located along the river—including Georgia Power's Plant Hammond, a coal-fired facility, and Inland Container's paperboard facility—which are large consumers of water. Diversions for these industries can reduce the amount of water further downstream in Alabama.

Atlanta currently draws 70 percent of its drinking water—about 250 million gallons a day—from the Chattahoochee River, and it releases nearly the same amount of treated wastewater in a day. As Atlanta learned in last summer's drought, in-stream flows from the Chattahoochee are insufficient to provide water in times of drought, much less to handle expected growth. In the late 1980s, therefore, Georgia contemplated constructing a new reservoir, West Georgia Regional Reservoir along the Talapoosa River, a tributary of the Coosa. The West Georgia Reservoir was to serve as another source of water for burgeoning Atlanta's metropolitan region. Alabama filed suit to stop the construction of the dam, out of concern for reduced stream flow for their state.

### **ACTing Up**

Federal legislation is required to create and administer interstate river basin compacts, and only a handful or so of interbasin river compacts exist. Therefore, the three states are forging new ground in attempting to come to an agreement over fair allocation of shared water supplies. To manage the dispute between Georgia and Alabama, Congress authorized the creation of the ACT River Basin Compact in 1997. The governor of each state was designated a voting member, and a federal negotiator was designated as a non-voting member. Georgia, mindful of Atlanta's growth, wanted to ensure water needs are addressed out to 2050. Three years and \$20 million later, no agreement is near.

Further complicating negotiations over water allocation is the lack of a drought management plan for Georgia. During the ongoing negotiations, Alabama has asked that Georgia sign a basin-wide drought-management plan before the allocation dispute is settled. This, however, is a Catch-22 for Georgia, which insists on signing such a plan only after the states arrive at agreement on flow levels and allocation. From Georgia's perspective, this makes a great deal of sense. Any drought management plan must depend on flow and in-stream requirements for downstream users. If Georgia agrees to guarantee a certain streamflow, the state could be at a serious disadvantage within two years after the allocation decision is made.<sup>1</sup>

### **Economic Angle**

Another serious obstacle to forging a tri-state agreement is the lack of sound economic projections of the costs and benefits of various

alternatives. Consider the estimated recreation dollars brought in by Lake Weiss, a hydroelectric impoundment that straddles the Alabama and Georgia state line about 15 miles west of Rome. Studies show that Lake Weiss contributes \$201 million in recreational income from out-of-state fishers and boaters to the regional economy. An additional \$1.25 million is generated from local use.<sup>2</sup> Since the lake is fed by the Etowah River, releases from Lake Allatoona affect the quality and quantity of water in Lake Weiss. Georgia state officials have proposed diverting 150 million gallons per day from Lake Allatoona by 2050 to meet metro Atlanta's needs.

Reliable projections for water use are also necessary to design and implement a sound drought plan. The state of Georgia suffered \$739 million in agricultural losses in 2000 alone. Furthermore, crop production is down 39 percent as a result of the drought.<sup>3</sup>

Drought conditions were so bad that the Georgia General Assembly rushed through legislation to pay farmers in the Flint River basin not to irrigate crops. This emergency funding was not planned in the state's budget, and legislators don't really know how this will be paid for. To generate research and discussion on the water issue, the General Assembly created the Flint River Regional Water Planning and Policy Research Center at Albany State University.

Georgia and Alabama have reached a tentative agreement on water management. Atlanta can draw water from both Lakes Allatoona and Carters, both within the ACT basin; and when the city is finished with the water, it can return the water to the Chattahoochee River located within the ACF

basin. Rome, though, can be adversely harmed since all water from the lakes comes from upstream rivers. It's not clear why Alabama has agreed to the interbasin transfer since it's obvious Alabama and Lake Weiss will be impacted from reduced flows.

### **Paying the Price**

Water resource managers in the tri-state region have failed for a number of reasons in their efforts to come to an agreement. They have not developed a watershed management plan, and they have not been able to agree on how to enforce a plan. If the three states involved in this dispute are to settle their differences, they will have to think outside the box.

The states should therefore consider alternatives to the traditional ways of approaching interstate watershed issues based on market forces. These include:

- Establishing a water permit trading program. Georgia Power and its sister company Alabama Power both draw water from the Coosa River basin. A permit scheme would allow both companies to trade surplus water and could benefit the river and downstream users. Georgia Power could sell the balance of its unused water withdrawal to Alabama Power. In turn, Alabama Power can benefit from increased water withdrawal from this credit. Electrical generation facilities already have precise accounting of the water used, so enforcing and trading water can be done to the last drop.
- Creating a water marketing program that facilitates full-cost pricing

for drinking water and sewage treatment within municipal regions. The customer in established service areas would pay the actual price of sewerage and water service rather than having the city or county subsidize water utility companies with tax-generated funds.

- Implementing full-cost pricing for new sewer and water lines, especially in rapidly growing regions like Atlanta. Full-cost pricing would allow utilities to recoup expenses directly for water infrastructure rather than hiding the real costs through bond issues and local sales and property taxes. Under this model, all new development must pay the actual cost for running water lines to the new site, not the subsidized or average cost pricing that most municipalities require.

- Privatizing existing water systems. This would also generate more-efficient management and develop new conservation technology.

When people pay for water they use, they decide when and how much they consume. This would encourage conserving water at every turn. Now homeowners turn on the tap and let it flow without much thought as to how much water is actually being consumed, except in times of drought, when government enforces water conservation and fines businesses and individual consumers for wasteful practices such as watering lawns. Full pricing would change that, without draconian political measures that coerce landowners to do what the city says.

Political decisions are not an answer to providing sufficient water supplies for residents of the Southeast. A more market-based approach to the equitable allocation of water can solve some of these problems. The lack of clear ownership and the lack of clear property rights within water resources translates to greater water use and wasteful water use.

The powers-that-be in these three states need to pursue sensible options without penalizing downstream users. In addition, a market-based strategy, in which the water that people use is accurately reflected by price, can go a long way toward minimizing water allocation problems. The future of all three states and their rapidly urbanizing areas lies in the hands of a very small group of people. The options they choose will set the path for the future.■

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### **NOTES**

1. Georgia Farm Bureau, ACT-Tri-State River Basin <<http://www.gfb.org/legis/actwater.htm>>.
2. Jason Landers, "Plan Would Cost Jobs, Start Civil War," *Rome News-Tribune* (November 14, 1999).
3. Oliver Yates Libaw, "Water Wars: Drought Ridden Southeast Battles over Use of Rivers" <<http://abcnews.go.com>>, August 14, 2000.

# Responding to the Water Crisis

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## Moving Beyond Crisis Management

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# Yankee Ingenuity

**I**n the United States, drought is a familiar visitor, though in the past five years some might say it has worn out its welcome. Until recently, the federal government treated drought like other natural disasters, such as tornadoes and earthquakes, with emergency response and relief. Recent droughts, from the West to the Southeast, however, have revealed the inadequacies of such short-term, reactive responses.

State organizations, scientific panels, and federal agencies have begun to consider integrated risk-management approaches, says Donald Wilhite of the National Drought Mitigation Center. The U.S. Department of Agriculture has been designated the lead federal agency for drought, and Congress has created a National Drought Policy Commission. Wilhite says that if we experience a few wet years, however, support for the new paradigm may evaporate. "It is critical for the scientific community and the public to hold policymakers to this commitment," he says.

Although we live on the most water-rich planet in the universe, most of the water is either too salty, or too dirty, for human use. The solution is to imitate nature's miraculous hydrological cycle by developing new technologies to refine and deliver purified and desalinated water, says Ronald Linsky with

the National Water Research Institute. In Orange County, California, for instance, micro-filtration techniques and disinfection with ultraviolet light can turn wastewater from a sewage treatment plant into drinking water.

Yet spot shortages of freshwater are a recurrent fact of life. In the western United States, where 35 percent of the water consumed comes from groundwater, farmers have historically had the right of prior appropriation of groundwater—that is, first come, first served—with the caveat, use it or lose it. Today, much of the available groundwater is pumped for irrigated agriculture, a practice that is often wasteful. In the meantime, population growth in urban centers is making it profitable to pump water long distances from the source. These changes are putting pressure on the aquifer, but also on legal doctrines that were designed to protect them, say political scientists Jeff Ashley and Zachary Smith. While some states lag behind, others are proving existing law can evolve along with changing usage. Arizona, for example, passed a Groundwater Management Act in 1980 that has substantially reduced overdrafting in the state.

Not only does human intervention in the hydrologic cycle—from dams to irrigation to destruction of adjacent lands—deplete surface and groundwater supplies, it has also upset the

delicate balance of aquatic ecosystems. Today, the rate of damage far exceeds the rate of restoration, says Virginia Tech biologist John Cairns Jr. Cairns argues that we have an ethical duty to restore these damaged ecosystems, preferably on the ecoregion level, for the benefit of humans and the biota.

Protecting endangered species is one aspect of environmental stewardship. Yet the Endangered Species Act, which has become one of the most powerful environmental laws ever, is flawed in many ways, says James Hansen, a congressman from Utah. Specifically, it is devoid of economic considerations. Hansen introduced, and Congress passed, a bill to authorize federal cost-sharing for recovery programs targeting endangered fish. As a result of federal support and interagency cooperation, endangered fish such as the Colorado pikeminnow and the razorback sucker are on the road to recovery.

As these examples show, human intervention in the natural hydrological cycle can result in degradation of water resources, but human ingenuity, when appropriately targeted, can ensure adequate water supplies while restoring water resources and protecting the environment.

*The Editors*



# Moving Beyond Crisis Management

*After nearly a century of ad hoc drought management, the United States needs a new paradigm centered on risk management.*

BY DONALD A. WILHITE

**T**o the casual observer, it may appear that in the past five years, drought has been a more common visitor to the American landscape. Drought conditions ravaged the southwestern and south-central states during 1995 and 1996, raising havoc in many economic sectors. It also caused serious environmental and social hardships. Drought has persisted in each year since, affecting most areas in the country on at least one occasion and several regions for three or more consecutive years.

From the policy perspective, the most significant droughts may have been the episode of 1995 and 1996, which sparked a series of initiatives, and the 1999 drought, which struck the eastern United States.

Extending from New England through most of the Southeast, this last drought persisted for nearly 12 months from mid-1998 through late summer 1999, and garnered considerable attention because of its wide-ranging and complex impacts on agriculture, forestry, water supply, and tourism and recreation.

Although drought conditions are common in the eastern United States, the intensity, duration, and spatial extent of this event caused great concern. This drought captured the attention of the major news media in the drought-affected area, and they questioned whether this region and the nation were adequately prepared for extreme

drought. This drought also coincided with the formation of the National Drought Policy Commission, a partnership between federal agencies and nonfederal representatives from tribal, municipal, and other interest groups. The Congress and the president charged the commission with determining a new direction for drought management in the United States—one emphasizing risk management over crisis management.

## **Too Little, Too Late**

**D**rought is normal in virtually all portions of the United States. It is a recurring, inevitable feature of climate. The Federal Emergency Management Agency (FEMA) estimates average annual

losses because of drought in the United States to be \$6 billion to \$8 billion, more than for any other natural hazard.<sup>1</sup> Yet the United States, as well as most other nations, is ill-prepared to deal with the consequences of drought.

Historically, our nation's approach to drought management has been to offer relief to the affected area. These emergency response programs are for the most part too little, too late. More importantly, drought relief does little if anything to reduce the vulnerability of the affected area to future drought events. On the contrary, considerable evidence suggests that government relief actually increases vulnerability to future events by increasing the recipients' dependence on government and by encouraging resource managers to maintain the very strategies that place industry, utilities, the community, and individuals at risk. Improving drought management will require a new paradigm, one that encourages preparedness and mitigation by applying the principles of risk management.

The lack of progress in drought preparedness is often blamed on constraints that are fallacious, no longer exist, or represent only a minor deterrent to improved drought management.<sup>2</sup> The argument goes that drought is unpredictable; that it is hard to monitor because it develops slowly; that data on climate and water supply are inadequate; that information delivery systems are inadequate; that a lack of coordination exists between and within government agencies responsible for monitoring drought, managing water supply, and planning for and responding to drought; and that suitable planning methodologies are unavailable. Drought planning sys-

tematically addresses these constraints, whether perceived or real.

Scientists and professional organizations have issued numerous calls for action to develop a national drought policy, but these have produced little in the way of progress. Yet, thanks to the National Drought Policy Act of 1998<sup>3</sup> and the subsequent report issued by the National Drought Policy

Commission—need a better understanding of the phenomenon before trying to establish plans that reduce vulnerability for future generations.<sup>5</sup>

Drought is different from other natural hazards such as floods, earthquakes, and tornadoes, which occur swiftly and with clearly visible results. All droughts originate from a significant reduction in

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## **Drought is the Rodney Dangerfield of natural hazards; it doesn't get the respect that other natural hazards do.**

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Commission to Congress and the president, we now can develop a coherent national policy that emphasizes drought preparedness and mitigation.<sup>4</sup> We are at a critical crossroads for drought policy. Will we continue down the road of crisis management or move toward risk management?

### **Profiles of Drought**

**D**rought may be one of the most complex and least understood of all natural hazards, affecting more people than any other hazard. It is a normal feature of climate and its recurrence is inevitable. Confusion about its characteristics, however, has meant that effective management in most parts of the world has received short shrift. Drought, in fact, is the Rodney Dangerfield of natural hazards; that is, it doesn't get the respect that other natural hazards do, given the magnitude of its impacts. Scientists, policymakers, and decision makers—including farmers and natural resource man-

agers—need a better understanding of the phenomenon before trying to establish plans that reduce vulnerability for future generations.<sup>5</sup>

precipitation extended over a season or longer. Humans can exacerbate drought, however, by over-allocating water supplies so demand may greatly exceed supply in water-short years. Poor land management practices such as overgrazing can also degrade the productivity of the natural landscape, thus increasing vulnerability to drought.

Many definitions of drought exist, reflecting the different climatic characteristics between regions and the wide range of impacts that can occur on various economic sectors and the environment.

Droughts are commonly classified as meteorological, agricultural, and hydrological. Meteorological drought occurs when there is a significant deficiency of precipitation compared with what is normal or expected over some extended period of time. Agricultural drought results when deficiencies in precipitation lead to a reduction in soil moisture that retards plant growth and development and, ultimately, yield. Hydrological drought, on the other hand, oc-

curs when an extended precipitation shortfall affects surface and subsurface water supply, which is measured by monitoring stream flow, reservoir and lake levels, and groundwater.

Hydrological droughts are usually out of phase with meteorological and agricultural droughts since a time lapse occurs between deficiencies in precipitation and the

periods of water shortage because of large investments in water storage and transmission facilities. Precisely because the eastern states have fewer droughts, the region is generally less prepared to mitigate and respond to its effects.

Drought differs from other natural hazards in several critical ways, which complicates monitoring, impact assessment, mitiga-

and extreme drought affected more than 25 percent of the country in 27 of the past 100 years. During the drought of 1934, more than 60 percent of the 48 contiguous states experienced severe or extreme drought conditions.

### **Human Component**

**M**any people consider drought to be largely a natural or physical event. In reality, drought, like other natural hazards, has both a natural and a social component, and human activity can either mitigate or worsen the physical effects. Of course, we can't change the weather, or meteorological drought, which occurs through persistent large-scale disruptions in the global circulation pattern of the atmosphere. But we can change some of the social factors that determine our vulnerability to drought.

Our population is not only increasing but also shifting from humid to more arid climates—such as from the Northeast and Midwest to the Sunbelt and the western states—and from rural to urban settings. Urban growth strains limited water supplies and water supply systems, especially during periods of peak demand. An increasingly urbanized population is also increasing conflict between agricultural and urban water users, a trend that will only be exacerbated in the future.

As the population increases, so does pressure on natural resources. To improve drought management, we need to use natural resources in a more sustainable manner. This will require a partnership between individuals and government. Further complicating the picture, in the future the effects of drought will fall harder on some economic

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## **Drought, like other natural hazards, has both a natural and a social component, and human activity can either mitigate or worsen the physical effects.**

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lowering of reservoirs or groundwater. In addition, water in hydrological storage systems such as reservoirs and rivers is often used for multiple and competing purposes such as drinking water, power generation, flood control, irrigation, and recreation. Competition for water in these storage systems escalates during drought, increasing conflicts among water users.

No wonder there's a lack of progress in drought management. If scientists can't agree on what drought is, or how severe it is, how can policymakers know when to act? A meteorologist, agronomist, and hydrologist may well provide three distinctly different responses to the question, are we in a drought? More important, they may all be correct.

Droughts occur more frequently in the West and usually last longer there, but the droughts of 1998 through 2000 have demonstrated the vulnerability of eastern states to severe and extended periods of low rainfall. Yet the West is currently better equipped to manage water supplies during extended

periods of water shortage because of large investments in water storage and transmission facilities. Precisely because the eastern states have fewer droughts, the region is generally less prepared to mitigate and respond to its effects.

Drought differs from other natural hazards in several critical ways, which complicates monitoring, impact assessment, mitiga-

tion, and response. First, drought is a slow-onset, creeping, natural hazard, so it's hard to determine when it begins and ends. Its effects often accumulate slowly over a considerable period of time and may linger for years after the event is over. Scientists and policymakers continue to debate the criteria for declaring an end to a drought.

Second, the absence of a precise and universally accepted definition of drought adds to the confusion about whether or not a drought exists and, if it does, its degree of severity. Realistically, definitions of drought must be specific to regions and impacts. Third, drought does not affect buildings, roads, and other structures, and it is more geographically widespread than other natural hazards. These peculiar characteristics of drought make quantifying its impacts and providing disaster relief far more difficult than for other natural hazards. The National Drought Mitigation Center, however, recently determined that for the 48 contiguous states, severe

sectors, population groups, and regions. Greater awareness of our environment and the need to preserve and restore environmental quality is placing greater pressure on all of us to be better stewards of natural and biological resources.

One thing is certain: continuing to address the effects of drought in a reactive, crisis-management mode will do little to reduce the impacts of these events in the future. In fact, this approach has been shown to increase vulnerability to drought in the long term because it increases dependence on government, which, in turn, decreases self-reliance. If the government continues to bail out the people most affected by drought, they will have no incentive to adopt methods to protect the natural resource base.

In arid and semi-arid Australia, the best land managers have learned that foresight and planning can lessen the devastating effects of inevitable long dry spells. By applying appropriate farm management practices, farmers can reduce many of the risks associated with drought, thus minimizing their losses.<sup>6</sup> Drought relief in Australia is now provided only during exceptional drought conditions. In the United States, however, the recipients of drought relief are typically those who do not implement appropriate management strategies when faced with impending drought or those who manage the land resource in nonsustainable ways by overgrazing, planting inappropriate crops, applying inappropriate tillage practices, or storing inadequate reserves of fodder for livestock. Urban areas may seek federal or state grants or loans when water supplies are at risk when, in fact, long-

range planning during a non-drought period could have averted or reduced the risk.

Should society subsidize poor land and water managers or reward those who plan ahead or adopt appropriate management practices? Risk management is aimed at the latter—crisis management, the former. The implementation of a national drought policy in Australia

plans largely focused on response efforts; today the trend is for states to place greater emphasis on mitigation as the fundamental element of a drought plan. Enhancing monitoring and early warning systems and conducting comprehensive risk assessments of vulnerable population groups, economic sectors, and areas are key components of the planning process.

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## **If the government continues to bail out the people**

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### **most affected by drought, they will have no**

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### **incentive to protect the natural resource base.**

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lia in 1992 changed that nation's approach to drought management. (See "Water Policy Adrift" in this issue of FORUM.) We should learn from their experience.

#### **Mitigating Disaster**

**I**n the absence of a coherent national drought-management strategy, an increasing number of states have stepped in to fill the void, creating their own drought plans during the past two decades.<sup>7</sup> In 1982, only three states had drought plans in place. By 2000, 30 states had developed plans and six states were at various stages of developing a plan. The basic goal of state drought plans should be to improve the effectiveness of preparedness and response efforts by enhancing monitoring and early warning, risk and impact assessment, and mitigation and response.

Plans should also contain provisions to improve coordination within agencies of state government and between local and federal government. Initially, drought

Other mitigation strategies include public education, conflict resolution actions among water users, and measures that augment supply and manage demand. Texas, for example, is developing a statewide drought plan that includes a requirement for local communities to develop drought plans. Georgia's drought plan will include a state framework with a series of more specific regional plans, such as for the metro Atlanta area and the Flint River basin.

Utah and Nebraska have revised their plans to further emphasize mitigation, and Colorado is in the revision process. New Mexico, which first developed a drought plan in 1998, now has mitigation as the primary ingredient of its plan. Texas, Hawaii, and Georgia are following a similar course. As states gain more experience with drought planning and mitigation actions, the trend toward mitigation is expected to continue.

Initially, states were slow to develop drought plans because the planning process was unfamiliar.

With the development of drought planning models and the availability of a greater number of plans for comparison, drought planning has become a less mysterious process.<sup>8</sup> As states initiate the planning process, they first study the drought plans of other states to compare methodology and organizational structure.

The rapid adoption of drought plans is also a clear indication of their benefits. Drought plans pro-

age. All of these actions can help to improve public awareness of the importance of water management and the value of protecting our limited water resources.

#### **Leading the Way**

**W**ith the tremendous advances in drought planning at the state level in recent years, it should come as no surprise that states have been extremely frus-

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### **Unlike other natural disasters, there is no lead**

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#### **federal agency for drought programs.**

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vide the framework for improved coordination within and between levels of government. Comprehensive, integrated early warning and monitoring systems enhance the delivery of information to decision makers at all levels. Many states now use the Internet to disseminate information to decision makers as well as to businesses, farmers, the banks that provide loans to farmers, and individual homeowners. These websites provide current information on drought severity, water-use restrictions, water conservation recommendations, key contacts within state and federal agencies, and other timely information.

Through drought plans, the risks associated with drought can be better defined and addressed with active mitigation and response programs. The planning process also allows the numerous stakeholders to be involved early and often in plan development. This increases the probability that conflicts between water users will not escalate during times of short-

trated with the lack of progress at the federal level. Early into the 1995-1996 drought, the lack of leadership and coordination at the federal level quickly became obvious, as attempts to access drought assistance programs were unsuccessful because federal programs had been discontinued, were underfunded, or in some cases had not received appropriations from Congress.

Unlike other natural disasters where Federal Emergency Management Agency (FEMA) provides leadership and coordinates federal response efforts, there is no lead federal agency for drought programs. This failure of leadership continued in later droughts. Recent initiatives toward developing a national drought policy are the direct result of those frustrations.

A national drought policy should establish a clear set of principles to govern the management of drought and its impacts. The policy should be consistent and equitable for all regions, population groups, and economic sectors

and consistent with the goals of sustainable development.

Drought policy should emphasize risk management through the application of preparedness and mitigation. In advance of drought, planning needs to be encouraged at all levels of government, monitoring and early warning systems must be integrated and improved, risk assessments should be conducted, and mitigation actions and programs should be identified and implemented. These actions will increase the level of readiness and improve operational and institutional capabilities for responding to a drought. Mitigation—short-term and long-term actions, programs, or policies implemented during and in advance of drought—reduces the degree of risk to human life, property, and productivity.

Emergency response, however, will always be a part of drought management since we cannot avoid or reduce all potential impacts through mitigation programs. In addition, it is probable that a future drought will exceed the drought of record and, therefore, the capacity of a region to respond.

Emergency response should be used sparingly, however, and only in a way that supports long-term goals and objectives.

A national drought policy should also reduce risk by developing better awareness and understanding of the hazard and the underlying causes of societal vulnerability. A risk-management approach promotes improved forecasts as well as integrated monitoring and early warning systems, encourages preparedness plans and mitigation programs at various levels of government, and supports a safety net

of emergency response programs that ensure timely and targeted relief.

### **Sense of Urgency**

**C**alls for action on drought policy and plan development in the United States date back to at least the late 1970s. Today, the federal government's failure to adequately address the spiraling impacts of drought has provoked a growing number of calls for action.

Clearly, the traditional, reactive, crisis management approach, which has relied on ad hoc inter-agency committees that are quickly disbanded following the end of a drought, isn't working. The lessons—the successes and failures—of these responses have quickly been forgotten, and the failures are simply repeated with the next event.

In response, a number of state organizations, scientific panels, and federal agencies—including the Western Governors' Policy Office, General Accounting Office, National Academy of Sciences, Great Lakes Commission, Interstate Council on Water Policy, U.S. Environmental Protection Agency, American Meteorological Society, Office of Technology Assessment, FEMA, Western Governors' Association, and Western Water Policy Review Advisory Commission—have issued calls for action.<sup>9</sup> The diversity of these stakeholders illustrates the extent of drought's impact on the economy and environment and the growing concern over the ineffectiveness of prior response efforts to address the complex, spiraling impacts of drought in a timely and equitable fashion.

More recently, in response to

the severe impacts of drought in 1996, FEMA was directed to chair a multi-state task force to address the drought situation in the Southwest and southern Great Plains states. The purpose of the task force was to coordinate the federal response to problems in the drought-stricken region by identifying needs, applicable programs, and program barriers. The task force was also directed to sug-

Fourth, states strongly requested that a single federal agency be appointed to coordinate drought preparedness and response.

The drought of 1996 also spurred development of a drought task force under the leadership of the Western Governors' Association. Formed in June 1996 as a result of a resolution offered by Governor Gary Johnson of New Mexico, the task force emphasized the importance

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## **Clearly, the traditional, reactive, crisis**

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## **management approach isn't working.**

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gest ways to improve drought management through short- and long-term national actions.

The final report contained several important long-term recommendations.

First, the task force called for the development of a national drought policy based on the philosophy of cooperation with state and local stakeholders. This policy should include a national climate and drought monitoring system to provide early warning of the onset and severity of drought to federal, state, and local officials.

Second, the task force suggested that a regional forum be created to assess regional needs and resources, identify critical areas and interests, provide reliable and timely information, and coordinate state actions.

Third, the task force asked FEMA to include drought as one of the natural hazards addressed in the National Mitigation Strategy, given the substantial costs associated with its occurrence and the numerous opportunities available to mitigate its effects.

of a comprehensive, integrated drought response.

The task force made several important recommendations. First, a national drought policy is needed to integrate actions and responsibilities among all levels of government. The policy should emphasize preparedness, response, and mitigation measures.

Second, states should develop contingency plans to provide early warning of drought to stakeholders, short- and long-term mitigation and response programs, along with triggers for the start-up and shut-down of these programs.

Third, a regional drought coordinating council should be created to develop sustainable policy, monitor drought conditions, assess state-level responses, identify impacts and issues for resolution, and work in partnership with the federal government to address drought-related needs.

Fourth, a federal interagency coordinating group should be established with a designated lead agency for drought coordination with states and regional agencies.

The FEMA and Western Governors' Association reports have spurred a number of important policy initiatives. In early 1997, FEMA, Western Governors' Association, the Small Business Administration, and the U.S. departments of Agriculture, Interior, and Commerce signed a memorandum of understanding calling for a part-

tional climate-monitoring system in support of that policy, as well as to develop state drought mitigation plans. Although impacts of drought occur mainly at the local, state, and regional level, this study concluded that it was imperative for the federal government to provide the leadership necessary to improve the way the nation

entists and managers to enhance observation networks, monitoring, prediction, information delivery, and applied research, as well as foster public understanding of and preparedness for drought;

- Develop and incorporate comprehensive insurance and financial strategies into drought preparedness plans;
- Maintain a safety net of emergency relief that emphasizes sound stewardship of natural resources and self-help; and
- Coordinate drought programs and resources effectively and efficiently and in a customer-oriented manner.

The National Drought Policy Commission further recommended creation of a long-term National Drought Council composed of federal and nonfederal members to implement the recommendations of the commission. The commission further recommended that Congress designate the secretary of Agriculture as co-chair of the Council, with a nonfederal co-chair to be elected by the nonfederal council members. In late 2000, Secretary of Agriculture Dan Glickman established an interim National Drought Council, pending action on a permanent council by the U.S. Congress.

The true legacy of the 1995-1996 drought is not likely to be its economic, environmental, and social impacts, but rather the policy initiatives that occurred in the post-drought period. These initiatives appear to be changing the way droughts are viewed, and they may change the way droughts are managed in the United States. The real question is whether these changes will result in permanent and substantive modifications in the way government entities deal with drought.

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## **A national drought policy is needed to integrate actions and responsibilities among all levels of government.**

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nership among federal, state, local, and tribal governments to reduce drought impacts in the western United States. This MOU resulted in the following actions:

- The formation of the Western Drought Coordination Council to address the recommendations of the western governors;
- The designation of the USDA as the lead federal agency for drought, to carry out the objectives of the MOU; and
- The establishment by USDA of a federal interagency drought coordinating group.

Concurrently, the Western Water Policy Review Advisory Commission, created by the Western Water Policy Act of 1992, reexamined western water policy.<sup>10</sup> One of the reports published by the commission summarized recommendations from recent studies on drought management that should be incorporated in future attempts to integrate drought management and water policy in the West.<sup>11</sup> The consensus of these studies emphasized the need to create a national drought policy and a na-

prepares for and responds to drought.

The severe drought of 1996 and the initiatives it inspired also led Senator Pete Domenici and Congressman Joe Skeen of New Mexico to introduce the National Drought Policy Act of 1998 in Congress. This bill created the National Drought Policy Commission to "provide advice and recommendations on creation of an integrated, coordinated Federal policy designed to prepare for and respond to serious drought emergencies."

In a report submitted to Congress and the president in May 2000, the National Drought Policy Commission recommended that the United States establish a national drought policy emphasizing preparedness. The goals of this policy would be to:

- Incorporate planning, implementation of plans and mitigation measures, risk management, resource stewardship, environmental considerations, and public education as key elements of an effective national drought policy;
- Improve collaboration among sci-

## Cloudy Future

**D**rought is a normal part of climate for essentially all regions of the United States. Likewise, drought relief has become a common feature of the national landscape. Shaped over the course of the past century and a half, this relief occurs primarily under a diverse, complex, confusing, and poorly coordinated ensemble of federal programs. It is reactive and does little to lessen the risks associated with future droughts. It is becoming increasingly clear that current land and water-supply management practices are not sustainable in the long term, especially given the variability of climate and the increasing demand on natural resources.

Although state and federal attention to improving drought management in the United States has been copious in recent years, including the National Drought Policy Act of 1998, little change in practice is visible to date, especially at the federal level. Federal response to drought conditions in 1999 and 2000 was reactive and short-term in scope—in other words, business as usual. To fill the vacuum, states have continued to be the most progressive actors in drought management, a trend that began in the early to mid-1980s. Regardless of progress by states, improved drought management requires an integrated approach between and within levels of government.

True, federal agencies are now speaking the new language of drought management, and phrases like “improved coordination and cooperation,” “increased emphasis on mitigation and preparedness,” and “building nonfederal/federal

partnerships” have become commonplace. Nevertheless, the mentality of most state and federal government agencies remains response oriented.

Existing institutional inertia of federal emergency response programs and the expectations of the recipients of assistance programs, however, encourage drought management to remain in a reactive, crisis-management mode. It is not yet apparent whether federal and state policymakers clearly understand the scope of the changes that will be required to invoke the new paradigm of risk management. When drought occurs, especially in election years, drought relief is one method that members of Congress use to send money home to their constituents.

The true test of whether we are making progress will be if Congress and the administration enthusiastically embrace the recommendations of the National Drought Policy Commission and other groups, provide adequate funding to support commission goals and recommendations, and direct federal agencies to modify existing policies and programs to emphasize mitigation and preparedness. If they do, they will shift funding from crisis to risk management and implement the new paradigm.

Only time will determine the dedication of the nation to this new approach to drought management. A continuation of widespread, severe drought in the next few years would certainly engender greater support for this new paradigm and help us continue down the path to risk management. The political will to change the way we manage drought appears to be genuine but may evaporate quickly if we experience

a series of wet years. Changing the momentum of the past will be difficult, but it is critical for the scientific community and the public to hold policymakers to this commitment. ■

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# Mother Nature's Machine

*By imitating natural processes, we can meet the water needs of current and future generations.*

BY RONALD B. LINSKY

All too often we read bold headlines claiming that the world is running out of water. Like so much of the information found in the media, such statements tend to exaggerate. So far, our planet is the only truly water-rich planet known in the universe. In retrospect, we might more accurately call the planet Water, not Earth.

The hydrologic cycle is a fundamental system of our planet. Massive amounts of water fall from the atmosphere onto the land as liquid rain. There it freezes into a solid state or runs off into the seas, where it evaporates back into a gaseous state and returns to the atmosphere.

After billions of years of modification and refinement, this gi-

gantic machine continues to serve as our planet's life insurance policy, and the process requires no technological intervention from humans to maintain its integrity.

As human populations expanded, however, they had profound effects on the water supply. Since time immemorial, people have faced water shortages resulting from droughts, floods, and contaminated supplies. The larger the population, the more severe the impacts.

In past millennia, when Earth was less crowded, people simply moved to a new location when water supplies were contaminated by natural or human means or evaporated in extended periods of drought. For today's modern urban societies, however, relocation is not a viable option.

## Imitating Nature

The cycle of finite resources used over and over has been fine-tuned over billions of years of evolutionary development on Earth. As the world's population grew, the need for resources grew accordingly and eventually became critical for the viability of human life. Fortunately, evolving ingenuity led to new discoveries that solved many of the problems associated with water distribution, treatment, waste management, and contamination. Today, most Americans have access to safe and reliable water supplies 24 hours a day, thanks to an array of remarkable technologies developed over the past 200 years.

From the early 1800s until midway through the 20th century, the federal government encouraged the westward movement of the population by promoting agriculture and ensuring reliable water supplies. During that period, the federal government and private entrepreneurs built dams and crafted water-diversion schemes at an unprecedented pace. Though the heyday of such innovation and investment in infrastructure is over, these technologies continue to provide utility customers with the highest quality of water in the world. Unfortunately, technology can't reduce the demand for water, so water providers will need to turn again to human ingenuity to usher in a new era of innovations.

## California Dreaming

Human populations have always settled along the shorelines of oceans, rivers, and lakes to take advantage of Mother Nature's remarkably efficient machine. People who settled near the oceans may

have enjoyed plentiful seafood and pleasant climate but were faced with very limited potable water supplies. In the United States today, over 50 percent of the population lives near shorelines of one type or another, and 20 percent of the population now lives in the Sunbelt, which stretches from Florida to California across Georgia, Alabama, Mississippi, Louisiana, Texas, New Mexico, and Arizona. These demographic shifts have placed increasing pressure on existing water supplies.

The water needs of the Sunbelt, with a population of over 50 million, are enormous. Southern California alone has 17 million residents, and its water utility managers face a daily challenge to meet these residents' need for water. The current residents of southern California alone consume 1.7 billion gallons of water a day. On an annual basis, that's 620 billion gallons, or over 2 million acre-feet per year.

If the current population stabilized at its current level, utility managers would probably not worry about water supply shortages in the near term. However, the California Department of Finance has projected that the state's population will grow at a rate of 600,000 people per year for the next 20 years. That's 12 million new residents by 2020. Of those new residents, 60 percent, or over 7 million people, will reside in southern California. Southern California water utility managers will therefore have to find, or make available, 36 million gallons a day of new water, or 13.1 billion gallons each year for the next 20 years to satisfy new customer demands. Is this a daunting challenge? Yes, but it is not impossible.

To meet the challenge, decision makers will have to consider the full array of policy alternatives and technological strategies. A variety of technologies that have evolved over the last several decades can contribute substantially to fulfilling the anticipated demands for additional supplies. But decision makers must remember that all the available naturally occurring water resources in the United States are known, and new water will come only from existing water.

We must now ask, what alternatives will be available for future generations?

The answer may lie in discoveries emerging from university research centers and industry laboratories, which are refining and making available technologies to produce water supplies of higher quality than Mother Nature's machine.

### **Trumping Mother Nature**

Throughout the world, water-supply projects have used a variety of technologies to filter agricultural irrigation waters, municipal wastewater, brackish coastal and ocean waters, and salt-laden ground and surface waters.

Consider the 22 countries that make up the Middle East and North Africa. This region contains the world's largest thermal desalination operations, which account for 50 percent of the world's annual desalinated water production, or over 4 billion gallons a year of drinking-quality water.

Several processes are used to create potable water by extracting salts from sea water. The two most common methods of desalination are thermal and membrane processes. The systems capable of the largest output of desalinated wa-

ter are thermal systems, found primarily in countries with abundant supplies of oil, for example Saudi Arabia, Kuwait, United Arab Emirates, and Bahrain. Thermal processes require substantial quantities of energy to heat seawater or brackish waters, convert them to water vapor leaving the salts behind, and condense and capture the vapor as fresh water. As their names imply, both multi-stage flash distillation and multi-effects distillation involve several stages and depend upon heating salt water in a boiler and lowering atmospheric pressure, which causes water to "flash," or evaporate rapidly, within the pressure vessels. The more stages in the process, the more desalinated water can be extracted from the system.

Vapor compression distillation systems are generally used in conjunction with these thermal processes. In the vapor compression distillation system, the heat for evaporating water comes from the compression of the vapor instead of the direct exchange of heat from a boiler. These technologies, which are used exclusively for desalting ocean waters, are energy intensive and therefore most useful in oil-rich countries.

Two other desalination techniques that require less energy in the process are the membrane technologies: reverse osmosis and electrodialysis. Both processes mimic nature and work by separating salts and water molecules as the water passes through micropores within the structures of thin membranes that prevent the salts from passing through.

Reverse osmosis systems operate in a closed environment under pressure that literally pushes water molecules through the mem-

brane and leaves the salts behind as reject material. This technology is used today to desalt seawater, wastewater, and agricultural irrigation waters very effectively. New plants currently in the works in Israel will provide substantial supplies for Israelis, Palestinians, and Jordanians. Finding solutions to the water problems in the Middle East is the key for reducing, if not eliminating, the tensions within the region.

Electrodialysis technology, on the other hand, operates under the principle that opposite charges—positive and negative—attract. Electrodes within the system cause the negative salt ions to travel toward the positive electrode, and the positive salt ions tend to move toward the negative electrode. The salt ions moving toward the electrodes pass through a membrane and leave behind the water molecules. However, membranes will allow only one type of ion—positive anions or negative cations—to pass through its pores, and electrodialysis systems must use both types of ion. These are arranged in alternate fashion within the system with space in between to allow the desalted waters to flow out. This technology is used very effectively with brackish water desalting operations common in coastal regions, inland seas, and areas with salt-laden water.

### **Global Thirst**

Because of increasing demands for reliable sources of water, desalination plants are increasingly coming on line in Europe, the United States, Japan, China, Africa, Pacific Islands, and the Caribbean areas. Significant improvements in technologies, moreover, are making the process more cost competitive.

This advantage has made desalination affordable for a number of regions that have always suffered from inadequate water resources. The island of Malta, for example, depends upon desalination of ocean water to provide over 60 percent of its fresh water needs at a cost of \$4.28 per thousand gallons. In Cyprus, desalinating the same amount costs \$4.20, and in the Virgin Islands, it costs \$7.81.

Tampa Bay Water, Florida's largest wholesaler, provides water to over two million people in the greater Tampa Bay area, which includes the cities of Tampa and St. Petersburg. On average, Tampa Bay Water provides 247 million gallons of drinking water every day to its customers. In the last several decades, however, rapid growth and economic development have taxed the groundwater supply. Under a master plan approved in 1995, Tampa Bay Water began a program to analyze and compare various options that were economically and technically feasible and environmentally sound.

In April 2000, Tampa Bay Water selected seawater desalination as a drought-proof, cost-effective means to diversify the water supply. The project undertook the development of a partnership between private and public entities, with the private sector incurring much of the financial risk. The partnership members include Tampa Bay Water, Tampa Electric, and Southwest Florida Water Management District (SWFWMD).

As a result, final cost to Tampa Bay Water will be \$1.60 per thousand gallons of desalinated water. When compared with other desalination costs in the world, the Tampa Bay price is the lowest achieved to date and compares fa-

vorably with traditional supplies from nondesalinated sources, which can range from \$0.40 to \$1.40 per thousand gallons, depending on location. The Tampa Bay Plant will initially produce 25 million gallons a day of high-quality drinking water with the potential at a later date to increase its capacity to 35 million gallons a day. This price has attracted significant international attention.

Another reverse osmosis plant is currently under construction at Point Lisas on the island of Trinidad, in the southeast Caribbean. This plant is designed to deliver 29 million gallons per day of high-quality drinking water at a projected price of \$2.00 per thousand gallons. This price is competitive with the price of treated fresh water from domestic supplies of various countries: Australia, \$6.76 per thousand gallons; Germany, \$5.60 per thousand gallons; United Kingdom, \$3.72 per thousand gallons.<sup>1</sup>

### **Reuse, Recycle**

Using water more than once through reuse or recycling is a strategy gaining wider acceptance and rapidly expanding throughout the world. Since 1964, Japan has promoted the concept of water reuse to avoid drought and today has expanded its use to include toilet flushing, landscape, urban waterscapes, agricultural irrigation, and cooling waters. But reclaimed water is not cheap. Current prices average \$11.32 per thousand gallon compared with the price of drinking water, \$14.12 per thousand gallons, in the city of Fukuoka on northern Kyushu Island.<sup>2</sup>

California has also long promoted water reuse. In the 1970s, the state set regulations for re-

claimed waters for beneficial uses. Commonly known as Title 22, this regulation sets out criteria for the quality of water for reuse applications. The beneficial uses include toilet flushing, industry, agriculture, recreation, and groundwater recharge. Reuse of water is beneficial to the environment as it reduces the amount of water that has to be mined or transported far distances. The term *reuse*, however, has caused difficulty in the past because of the public's perception of used water.

Unfortunately, the public doesn't perceive that recycling, or reusing, water mimics the elegance of Mother Nature's machine. All the waters of the world are cycled over and over again, day after day, year after year, century after century, millennium after millennium. Every living creature on Earth drinks recycled water every day. Today's water reuse technologies simply enhance nature's machine by speeding up the process to meet the increased needs of the expanding population. Every drop of water available should be used a minimum of 12 times before it is given back to Mother Nature's machine.

### **Pure, Clean Water**

Orange County, California, is planning a groundbreaking project that may help promote acceptance of reused water across the nation. The planned water treatment plant will use new technologies to provide 100,000 acre-feet per year of high-quality water to more than 2 million residents. The recycled water will be potable, and it will help conserve the limited groundwater supplies of the region.

The Groundwater Replenishment System is a joint venture of the Orange County Water District and the Orange County Sanitation District. A cost-effective solution to anticipated water needs, this project will use advanced water-treatment techniques to take treated wastewater from the sewage treatment plant and purify it to levels that far exceed current EPA drinking water standards.

The system uses microfiltration membranes to remove suspended particles. Microfiltration is the same type of technology used in the beverage industry and in computer-chip manufacturing. It is also used to sterilize medicine that cannot be heated.

Microfiltration will be followed by reverse osmosis filtration, which acts like a strainer to allow only water molecules to pass through while filtering out all the minerals and contaminants, including salts, bacteria, viruses, and pesticides. Then the water will pass through ultraviolet disinfection that acts as concentrated sunlight and serves as another barrier of protection. Ultraviolet disinfection provides extra assurances that unwanted contaminants will not pass through the system and that the water will be of the highest quality possible.

By 2020, over 32 billion gallons of water will be reclaimed or recycled from used waters that are now being discharged to the ocean at a daily rate of over 200 million gallons. The projected costs of the new water from the project will be in the range of \$1.80 to \$2.50 per thousand gallons or \$600 to \$800 per acre-foot.

The groundwater replenish-

ment system will provide a new drought-proof water source and will reduce the need to purchase imported water. In addition, the system will improve the quality of the groundwater basin by lowering the mineral content when it is injected and stored in the groundwater basin.

After centuries of extraction, we are now faced with the challenge of finding adequate sources of water from dwindling natural resources. The problem is not a lack of appropriate technology, but rather of diminishing resources. People are fast becoming the abundant resource, while natural resources are fast becoming scarce.

Water is an asset that provides services of real value. To ensure the maintenance of these valued services for future generations, we must invest in the asset. The hydrologic cycle is the planet's life insurance policy. That's why water reuse, recycling, or reclamation are absolute necessities if generations to come are to enjoy an economically and environmentally secure future.■

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# Western Groundwater Wars

*Will increased demand for groundwater and new population pressures put western farms out of business?*

BY JEFFREY S. ASHLEY AND ZACHARY A. SMITH

**M**ost people take water for granted. As long as it flows out of the tap in a relatively unadulterated form and doesn't look, smell, or taste bad, we give very little thought to where water comes from, how it got into our homes, or what impact changing water uses will have on our communities. In the arid western United States, however, one of the greatest natural-resource management problems in coming decades will be the quantity of available groundwater, its quality, and how it is to be used.

In large sections of the West, groundwater is the only depend-

able source of water. For the 19 western states as a whole, roughly 35 percent of the water consumed comes from the ground.<sup>1</sup> Furthermore, dependence upon groundwater in many areas will increase in the future since the best surface water sources—rivers, lakes, and streams—have largely been developed or appropriated. As dependence on groundwater increases, a number of subtle shifts in local management policy, economics, and uses will occur. In areas where inexpensive surface water has been available, for example, additional agricultural expansion will be possible only through pumping more-expensive groundwater. In addition, popu-

lation shifts from rural areas to cities will cause changes in patterns of land use, economic activity, and the sociopolitical composition of the area. The twin pressures of existing agricultural water use and the need to facilitate new population concentrations will, without proper management, eventually deplete groundwater supplies through overdrafting, as water is extracted at a rate that exceeds recharge.<sup>2</sup>

Moreover, as groundwater supplies become depleted, and the cost of water increases, the rising price will result in changes in water usage. In some areas, groundwater will become uneconomical for agricultural use, and the lands will revert to dry farming or go out of production altogether. These changes have social, political, aesthetic, and economic impacts and will change the character of local communities and the West as a whole. The importance of groundwater cannot be overstated.

## **Resource at Risk**

It is estimated that more than 90 percent of freshwater in the United States is in the form of groundwater. The balance is in lakes, rivers, and streams.<sup>3</sup> Use of groundwater has increased dramatically in the recent past. From 1945 until 1980, groundwater use more than quadrupled, increasing from 21 billion to 88 billion gallons a day.<sup>4</sup> In the mid-1990s, approximately one-half of all the people in the United States used groundwater as a primary source of drinking water.<sup>5</sup> Nationally, groundwater provides 39 percent of the water used in public supply systems. Groundwater also provides 75 percent of the water used for rural domestic consumption and livestock pur-

poses, 37 percent for irrigated agriculture, and 2 percent for self-supplied industrial purposes.<sup>6</sup>

In the West, however, where 33 percent of the freshwater comes from groundwater sources, most of the water, 78 percent, goes for irrigated agriculture. Public supply systems consume 14 percent, and rural domestic and livestock use accounts for 4 percent.<sup>7</sup> Although these percentages vary significantly from state to state, it is clear that in the West, where agriculture plays a large role in the economy, groundwater will weigh heavily in determining the future and direction of the economy. And, as we might expect, shifts away from agricultural uses will have ripple effects throughout those economies. Unfortunately, despite its obvious importance, many people do not understand the nature of groundwater.

### **The Resource**

When precipitation falls to the earth as rain or snow, some percolates through the soil to a water table, which is the top of what is referred to as the zone of saturation. A zone of saturation is also fed by surface water from wetlands, lakes, and streams. Water that reaches the zone of saturation from the surface is said to percolate; hence, such water is sometimes referred to as percolating groundwater. Whatever the source, groundwater moves very slowly, its actual speed depending on the composition of the material in which it is held. When the water in a saturated zone is sufficient and the composition of the material is adequate to store amounts of water for human use, it is referred to as an aquifer.

There are two types of aquifers:

confined and unconfined. Confined aquifers, also called artesian aquifers, are overlaid by impervious matter such as clay or shale. These aquifers are under greater than atmospheric pressure; hence, the water sometimes flows to the surface. Unconfined aquifers are those that are under atmospheric pressure, and water level variability in such aquifers depends on natural conditions, particularly the rate of replenishment, or recharge, to the water table. When water is withdrawn from an aquifer at a rate that is greater than its rate of natural or artificial replenishment, the aquifer is said to be mined, or overdrafted. When such conditions continue indefinitely, the water table drops and the resource is depleted. Then, of course, pumping stops. In such situations pumping often stops before total depletion because the increased cost of drawing the water from greater depths makes further use of the water uneconomical.

### **Evolution of Technology**

Although humans have been taking water out of the ground since ancient times, it has only been within the last century—indeed within the last few decades—that the means have been developed to withdraw large amounts of water from the ground. For most of the history of the West, the major problem has been how to get water out of the ground.

The first successful and widely adapted device for extracting groundwater was the windmill. Although windmills took various shapes and forms, the early designs all had in common a dependence on erratic wind patterns, inefficiency, and overall low productivity. A windmill with a 25-foot

diameter wheel, which was large, operating in a 16-mile-an-hour wind was capable of lifting approximately 37 gallons of water a minute from a maximum depth of 70 to 80 feet. Although such yields were sufficient for domestic uses, they did not allow for widespread irrigation.<sup>8</sup>

After the windmill came the centrifugal pump. Early centrifugal pumps had a number of serious drawbacks. First, they had to be located within 20 feet of the water table. This sometimes required quite deep and relatively wide pits, with the pump operating at the bottom of the pit. Since these pumps were expensive to purchase and operate, their use was limited to high-value crops such as rice. These early pumps were also often belt driven and powered by steam, requiring frequent adjustments and constant care. Later, steam was replaced by low-compression oil-burning engines. The cost of such pumps in the first decade of the century was approximately \$4,000.<sup>9</sup>

Through the 1920s, pump designs improved. Centrifugal pumps were developed that allowed for operation at much greater depths and with higher capacity. Inefficient steam and low-compression oil-burning power plants were replaced by hooking up an old car motor on a direct drive to the pump. By the 1920s, the cost of the pump, power plant, and drilling had dropped to approximately \$2,000. Further improvements in pump design in the 1930s and the availability in many areas of cheap electric power combined to rapidly increase the number of wells and the yield of these wells throughout the West and the Midwest. By the end of the decade, the techno-

logical problems associated with groundwater pumping had largely been overcome, and concerns over water supply began to emerge.<sup>10</sup>

Improvements in pump design allowed the total amount of groundwater withdrawn for western irrigation to increase from relatively small amounts in the early 1930s to about 10.7 million acre-feet by 1945 and up to 56 million acre-feet by 1975.<sup>11</sup>

Most of these early expansions took place on the high plains, a semi-arid region characterized by relatively low rainfall—averaging less than 20 inches, or about 50 centimeters—and climatic extremes. From World War II to the mid-1960s, the greatest increases in groundwater use were concentrated in the Southern Plains, most notably in the area surrounding the Texas Panhandle.<sup>12</sup> Groundwater withdrawal for irrigation in the Southern Plains grew from less than 1 million acre-feet in 1945 to approximately 13 million acre-feet by 1965. The same technological advancements allowed for increased use of groundwater in the Northern Plains, home to 28 percent of the nation's farmland, although that expansion occurred somewhat later.<sup>13</sup> In 1950, 26 percent of the water used in irrigation in the Northern Plains came from the ground. By 1975 this had increased to 78 percent.<sup>14</sup>

The development of center-pivot sprinkler irrigation systems has also facilitated the expansion of groundwater use in the West. First patented in 1952, center-pivot irrigation systems are made up of a long line of sprinklers that move in a circle around a fixed pivot like the large hand of a clock. Water is supplied from the central pivot point. Most systems are de-

signed to irrigate a quarter of a section of land—160 acres—but because of the circular pattern, they actually irrigate only 130 acres. Sprinkler irrigation and center-pivot irrigation have the advantages of using less water than flood or furrow irrigation. Sprinklers may be used in areas with sandier soil or hillier land than is possible with other types of irrigation. Also, given that one person can irrigate from 10 to 15 quarter sections—1,300 to 2,000 acres—center-pivot systems can reduce labor costs significantly.<sup>15</sup>

### **Evolution of the Law**

The technological changes that facilitated rapid expansion of groundwater pumping and the development of irrigated agriculture in the West put pressure on the legal doctrines governing groundwater use and ownership. As it became possible to withdraw greater amounts of water from greater depths, competition for water developed in some areas.

Legislatures in the West reacted to conflict over groundwater resources in a variety of ways. They changed their laws—or perhaps not—depending upon the controversies involved, the participants, the interests, and the pressure lawmakers felt. Because of early conflicts over groundwater, some states—New Mexico, for example—were quick to write relatively comprehensive groundwater management statutes. In other states, notably Texas and California, early water law has changed greatly yet retained significant parts of the law as it existed prior to the rapid development of groundwater resources. In some states, the line between the old and the new laws is not always

clear, and this lack of clarity amidst competition for and demand on the resource has sometimes led to what many feel are inefficient uses and overutilization of groundwater.

There are, in fact, four major groundwater law doctrines in the United States, and groundwater law has changed since the turn of the century. The four primary legal doctrines governing groundwater use are the English—or common law—rule of absolute ownership, the American rule of reasonable use, the correlative rights doctrine, and the doctrine of prior appropriation. Generally, groundwater law in the western states has evolved during this century from the English, or common law, rule of absolute ownership to either the American rule of reasonable use or, in most western states, the doctrine of prior appropriation.

■ **Absolute Ownership.** The common law, or absolute ownership doctrine, holds that the water beneath one's land is the property of the landowner and may be withdrawn, without malice, with no regard to the effect that withdrawals have on any other landowner. In theory, and in practice in many areas, this has meant that landowners could pump at will the water beneath their lands as well as the water beneath the lands of their neighbors. The absolute ownership doctrine was developed in England and transferred to the relatively wet East, where it is largely still the law.

This doctrine works reasonably well in areas where water is abundant. However, in the more arid western states, many courts and legislatures, familiar with water law in other parts of the country, have adopted the common law

rule. In early western history, minor amounts of groundwater were withdrawn because of technical obstacles and relatively small demand. Since competition for groundwater resources had not yet become an issue, the absolute ownership doctrine seemed the reasonable course to pursue. However, when competition for water did develop in the West, the drawbacks to the absolute ownership doctrine in an arid environment became apparent. It was shortly after competition for water developed—as early as the late 1800s—that modifications of the rule started to be made.

One case that dealt with problems in the rule was *Bassett v. Salisbury Mfg. Co.* (1862). In this case, the court recognized the potential dangers of absolute ownership for both the resource and for users without high capacity pumping devices. Short of any modification, it was clear that there was nothing in place to dissuade high-capacity pumpers from depleting the resource and leaving other users at their mercy. Moreover, prior to any change in the rule, even malicious depletion aimed at intentionally harming a neighbor was legal under strict interpretation of the law.<sup>16</sup>

■ **American Rule.** One modification made by many courts in the West was the reasonable use doctrine, or the American rule. Basically, the reasonable use doctrine limits a landowner's right to the water beneath his or her land to the amount necessary for some reasonable and beneficial purpose on the land above the water, such as domestic uses, irrigation, and livestock watering. Wasting water or diverting it off the land was not considered a reasonable beneficial

use if such use interfered with the right of adjacent landowners to use the water beneath their own lands for the beneficial use of those lands.

While this approach may sound rational, it is not without problems. Most notably, there is often conflict over the definition of "reasonable" use—a concept discussed below.

■ **Correlative rights.** Some states, notably California, developed the correlative rights doctrine as an alternative to the absolute ownership doctrine. This approach is an extension of the American rule of reasonable use. Basically, the correlative rights doctrine recognizes the landowner's right to use the water beneath his or her lands but limits that right somewhat by providing that landowners overlying a common source of groundwater have rights to a reasonable amount of that water when the water is applied to a reasonable beneficial use on the land overlying the groundwater basin.

Under the correlative rights scheme, the quantity of a water right is often determined by the amount of acreage owned; there is a correlation between proportions of water supply allocated in times of shortage and the ration of land overlying the aquifer. The problem with this approach, in addition to the "reasonable use" dilemma inherent in the American rule, is that it ignores traditional uses of water and actual need—a person holding a smaller piece of land may actually require more water than the law allows, while larger owners may need less. This can lead to hostilities and attempts at gaining water through adverse possession or prescription—a practice that often encourages overdrafting.<sup>17</sup>

■ **Prior Appropriation.** Most western states have adopted the prior appropriation doctrine. The prior appropriation doctrine simply provides that the first appropriator of water, by putting that water to beneficial use without waste, has a right to continue that use. And such rights are superior to the rights of people who appropriate water at a later date. In prior appropriation states, water rights are usually administered by a state office or official—often a state engineer—through a permit procedure.

The strength of the doctrine of prior appropriation—its permanence and predictability—has also become the greatest source of potential conflict. As demographics in the West change and become more urban-based, the doctrine tends to favor those who perfected their water rights in more agrarian times. As we will see below, the degree to which the doctrine of prior appropriation is able to be manipulated and adapted to fit changing times will determine the social, political, and economic future of the West as it relates to water.

### Legal Concepts

Besides these four major doctrines that have shaped western water law, two legal concepts also play an important role in the evolution of the law in modern times. The concept of beneficial use repeatedly comes up in the domain of groundwater policy and law. The Utah Code is typical, stating that beneficial use "shall be the basis, the measure and the limit of all rights to use water in this state."<sup>18</sup>

The beneficial use concept was developed during the 19th century to encourage economic effi-

ciency. Although some uses have always been considered beneficial—for example, water for domestic purposes or for irrigation, manufacturing, or stock watering—outside these traditional uses, conflict and controversy sometimes arise over what constitutes a beneficial use. For example, some state legislatures or courts, such as in Arizona and Colorado, have found water needed for the protection and propagation of fish to be a beneficial use, while others, including Idaho and Utah, have not.<sup>19</sup>

Courts and state legislatures have also been split on the issue of whether or not water necessary for recreation, aesthetic, or scenic uses is a beneficial use of water.<sup>20</sup> This can be a problem in groundwater regulation because of the relationship between surface water and groundwater in streambeds. Hydraulic continuity, or the interrelationship between surface and groundwater, is a particularly hot topic in the state of Washington, where groundwater permits are increasingly denied because of the impact withdrawals would have on stream flow. If surface water for recreation, aesthetic, or scenic uses is protected, many groundwater permit applications—most often of new users of water—will have to be denied. While such an approach is environmentally sound, it is not politically popular.<sup>21</sup>

Another issue in the development of groundwater law in some states is whether or not water rights may be acquired by adverse possession. Basically, adverse possession, or adverse use, allows for the acquisition of water rights by the open and notorious use of someone else's water for some statutory period, usually five years.

Acquiring rights by adverse use or adverse possession is not unique to water law, but its application in water law in some states has proven problematic.<sup>22</sup>

The application of legal principles in the West may vary significantly even though states may, in theory, follow the same doctrine. New Mexico, for example, follows the prior appropriation doctrine and manages groundwater quite differently from North Dakota, which follows the same doctrine. In New Mexico, where, for all practical purposes, many groundwater basins are virtually nonrecharging, those basins are managed with the understanding that they will eventually be depleted. In contrast, in North Dakota, many groundwater basins do recharge regularly, and that water is managed, for the most part, on a safe-yield basis; that is, the amount of water withdrawn from an aquifer roughly equals the amount of water returning naturally or artificially to the aquifer over an extended period of time.

#### **What the Future Holds**

To understand groundwater law, it is crucial to consider the social functions water law has served and how changes in the law have mirrored changes in water use and society. Stability of water ownership is essential for economic growth and long-term planning. Farmers or cities are not likely to build expensive water development facilities if their title to the resource may be called into question in the future.

Early in the history of the West, policymakers may have believed that the common law doctrine, or the absolute ownership rule, would provide the stability neces-

sary for long-term planning. In fact, before competition for water resources intensified, the common law doctrine did provide that stability. However, when competition began to create conflict for groundwater resources, it became clear that one pumper might find the use and enjoyment of his or her groundwater threatened by the activities of pumping on adjacent lands. Converting to the doctrine of prior appropriation, as most western states did, provided the stability necessary for pumpers to understand what their rights were and to plan for the long-term use and development of their water.

This same stability, however, has tended to favor those who acquired their water rights early on, such as irrigators, and to the extent that water laws prevent the transfer and change of ownership of water rights—as they do in some states—the law has favored those historical uses and has prevented change in water-use patterns and the development of alternative uses.

So groundwater law has provided the stability necessary for economic growth and expansion. Yet, more recently, that same stability has, in some states, prevented changes in water use and, some would argue, further economic growth and development. Politically, this can lead to pressure for unsound management of the resource—for example, the attempts by some political factions in parts of Washington to deal with groundwater and surface water appropriations separately to accommodate a greater number of uses.

In general, the law has proven itself to be capable of adaptation to change. Some states, however,

have lagged behind in responding to changing groundwater use and conditions. The result, in some cases, is that the resource is poorly managed, if managed at all. Most of the states, however, seem to be doing a fairly good job of managing groundwater on a statewide basis. Hawaii, for example, passed a comprehensive water code in 1987, and Arizona's 1980 Groundwater Management Act has led to a substantial decline in statewide overdrafting.<sup>23</sup>

Groundwater law is only one part of groundwater policy. In some states, for example, who gets the water depends more on who can afford to drill the deepest hole or sustain the longest court battle than it does on the formal policy followed in the state. Just as some air polluting corporations can sustain their practice in the face of litigation—the benefit of continued operations offsets any penalties or attorney fees—some groundwater pumpers may find that the use of the water apart from traditional appropriation systems justifies the cost of a potential court battle.

In other states, in spite of glowing constitutional language about beneficial uses and preventing waste, economic and political realities make it beneficial for farmers and others to waste a great deal of water. Appropriative rights require use of the resource, and water left in the ground for an extended period of time can revert to the state for reallocation to other users. There is often an incentive to continue using water, even when such withdrawals are unnecessary, to protect an existing right for future use.

Many parties are involved in groundwater use and control. Pub-

lic servants in federal, state, and local water resource and natural resource agencies, legislators and their assistants at all levels of government—as well as researchers in a variety of fields, including geology, hydrology, law, public administration, and political science—are all among the actors with an interest in groundwater use and management.

Although groundwater has always been an important supply of water in the West and today provides roughly 35 percent of the total water used in the 19 western states, demands on groundwater will increase significantly in the future. Surface-water sources in the West are, for the most part, already developed or appropriated. Given federal budget constraints and the resistance of various administrations, beginning with the Carter administration, to building new surface-water delivery systems, it is unlikely that major new surface-water systems will be built in the future. Consequently, demands on and interest in groundwater will undoubtedly increase in the future.

As demands and interest increase, so will the inherent conflicts that have developed around the distribution of groundwater. The early and rapid growth of groundwater pumping and agricultural development in western states resulted in the vesting of the majority of water rights to farmers. This laid the groundwork for future conflicts over water use and development, as other users have competed with agriculture for rights to water.

Often, the political battles for water have become heated and fierce, and the stakes are high. When Mark Twain commented

that “whiskey is for drinking and water is for fighting,” he could not have known how fierce the fighting would become. These battles are likely to continue, and the outcome will determine the future of the West.<sup>24</sup>■

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## NOTES

1. Alaska, Arizona, California, Colorado, Hawaii, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, Wyoming.

2. Estimates vary on depletion rates across states as a number of factors come into play. The type of aquifer, permeability, precipitation, and management of the resource will all affect the degree to which an aquifer is depleted or remains at a steady state. Thus, any attempt to generalize depletion of western groundwater becomes problematic. For more on the status of individual states, see Jeffrey S. Ashley and Zachary A. Smith, *Groundwater Management in the West* (Lincoln, NB: University of Nebraska Press, 1999).

3. Wendy Gordon, *A Citizen's Handbook on Groundwater Protection* (New York, NY: Natural Resources Defense Council, 1984), p. 10. Although estimates of total groundwater storage in the United States are problematic at best, estimates range from 90 percent to over 98 percent of freshwater.

4. *Ibid.*, p. 11.

5. National Resource Council, *Groundwater Recharge Using Waters of Impaired Quality* (Washington, DC: National Academy Press, 1994), p. 1.

6. U.S. Geological Survey, Circular 1081 (Washington, DC: U.S. Government Printing

Office, 1993), pp. 13-17.

7. In million gallons per day. Public supply, rural and livestock, irrigation, and self-supplied industrial figures are for groundwater use only. The percentage of water used in a state that is taken from the ground can be found by dividing the total groundwater figure by the total freshwater figure. Compiled from data in U.S. Geological Survey Circular 1081 (1993).

8. Charles Bowden, *Killing the Hidden Waters* (Austin, TX: University of Texas Press, 1977), pp. 82-119.

9. *Ibid.*

10. Zachary A. Smith, *Interest Group Interaction and Groundwater Formation in the Southwest* (Lanham, MD: University Press of America, 1985), ch. 10.

11. Kenneth D. Frederick and James C. Hanson, *Water for Western Agriculture* (Washington, DC: Resources for the Future, 1982), p.

73. An acre-foot is the amount of water that would cover one acre to a depth of one foot, or about 325,000 gallons.

12. References to the Southern Plains generally refer to areas of New Mexico, Texas, and Oklahoma.

13. References to the Northern Plains generally refer to Colorado, Kansas, Nebraska, Wyoming, North Dakota, South Dakota, and Montana. The common denominator among all plains states—northern and southern—is the reliance on the High Plains, or Ogallala, aquifer.

14. *Ibid.*

15. Frederick and Hanson, *Water for Western Agriculture*, p. 163.

16. David H. Getches, *Water Law*, 3rd ed. (St. Paul, MN: West Publishing, 1997), p. 249.

17. See, for example, *City of Pasadena v. City of Alhambra* 33 Cal. 2d 908, 916 (1949) and *City of Los Angeles v. City of San Fernando* 14 Cal 3d 199 (1975).

18. Utah Code sec. 77-1-3.

19. Getches, *Water Law*, pp. 97-98.

20. For more on beneficial use, see Getches, *Water Law*. In this text, Getches describes the complexity of beneficial use and the ever-changing nature of the concept. He writes, "All prior appropriation states consider domestic, municipal, agricultural, and industrial uses to be beneficial uses. Recognized types of beneficial uses may be defined more elaborately by statute or case law. Just because a use is among the types listed, however, does not mean it will be deemed 'beneficial' under the circumstances for all time. Indeed, yesterday's beneficial use may be unreasonable or wasteful, and thus impermissible, today. In *Empire Water & Power Co. v. Cascade Town Co.* (205 F 123 (CCA 8th Cir. 1913), a federal appeals court refused to consider recreation a beneficial use. Most states now have accepted recreation as a beneficial use. Some even specify that scenic or aesthetic uses are beneficial." For how long? Nobody knows.

21. See Ashley and Smith, *Groundwater*

*Management in the West*.

22. Appropriation rights generally cannot be lost through adverse possession. However, some courts—such as those in Idaho, Montana, and Utah—have ruled that a junior appropriator could take over the rights of a senior appropriator through adverse possession. (See Getches, *Water Law*). The problem lies in when to apply the doctrine and when not to. To date, there is no clear consensus, and the mere threat of adverse possession leads to potential mismanagement of the resource. Rather than allow water to sit when it is not needed, an appropriator feels pressured to use the water in a questionable manner rather than allow someone else to use it, which might contribute to a future adverse possession claim. For example, some might argue that Arizona's Water Banking Authority is nothing more than a veiled attempt to keep California from "borrowing" Colorado River Water. See Ashley and Smith, *Groundwater Management in the West*, for more on the Arizona Water Banking Authority.

23. See Ashley and Smith, *Groundwater Management in the West*, for a summary of the groundwater law and problems in the 19 western states.

24. Portions of this article appeared originally in Zachary A. Smith, *Groundwater in the West* (San Diego, CA: Academic Press, 1989).



# Life Support

*Ensuring the health of the planet's aquatic ecological system is a delicate balancing act.*

BY JOHN CAIRNS JR.

*Where there is no vision, the people perish.*  
Proverbs 29:18

**T**he basic material needs of humans are food, shelter, and freshwater. Only a tiny fraction of the planet's water is fresh, and a significant portion of this fraction is presently locked up in polar ice caps and glaciers.

Constant reuse of the finite supply of freshwater is made possible by the biota of aquatic ecosystems, which are most productive when they are robust and healthy. Since the health of the aquatic ecosystem is closely coupled with the condition of the adjacent land, however, ensuring this healthy state requires constant monitoring of both land and water ecosystems.

Aquatic ecosystems are damaged in a variety of ways—for example, through bad land management; drastic alterations of the

hydrologic cycle by dams, irrigation, and destruction of wetlands; anthropogenic wastes; introduction of exotic species; biotic impoverishment; and erosion of adjacent land masses. Since humans depend upon ecological and technological life-support systems, it is essential to maintain an optimal relationship between the two so that neither damages the other.

Abundant case histories show that aquatic ecosystems can be successfully restored to a healthy state, but the worldwide rate of damage still exceeds the rate of restoration by a substantial margin. Maintaining a balance between the rate of damage and the rate of restoration is a minimal requirement for sustainable use of the planet. If quality of life is to be maintained in the 21st century, as populations and affluence increase, restoration must exceed damage by a substantial margin.

The National Research Council defines restoration as the return of an ecosystem to a close approximation of its condition prior to disturbance.<sup>1</sup> In restoration, damage to the structure and functions of the resource is restored.

Recreating the form—the structure—without the functions or recreating the functions in an artificial configuration bearing little resemblance to a natural resource does not constitute restoration.

## Value Systems

The functions of ecosystems that are perceived as valuable to human society—flood control, production of food and fiber, good water quality, atmospheric gas balance—are crucial components of the restoration planning process; otherwise, society would almost certainly neither restore damaged ecosystems nor preserve and maintain them once restored. Therefore, we must determine the optimal balance between these human values and purely ecological values, such as population interactions, nutrient cycles, and energy transfers throughout an ecosystem. In so doing, we can greatly increase our environmental literacy in both areas.

If the purely ecological values are slighted, the restored system will not likely be self-maintaining. And if the human values are slighted, the project is less likely to be funded.<sup>2</sup>

## Problems of Scale

Whenever feasible, ecological restoration should be carried out on a large scale—encompassing at least an entire watershed. Restored systems on a large scale are more likely to be self-maintaining than systems that are small or fragmented. From an ecological stand-

point, planning at the landscape, or better yet bioregional, level therefore makes good sense.

As a general rule, the larger the system, the larger the number of stakeholders who, in turn, are likely to increase the level of contention and conflict. But this situation is not inevitable. Consider, for instance, the restoration of the large Kissimmee riverine-floodplain system, which needs to be understood in the larger context of the effort to restore the Florida Everglades. The Kissimmee was once a broad, meandering 103-mile-long (166-kilometer) waterway that drained an upper basin consisting of a chain of lakes. In 1961, the U.S. Army Corps of Engineers began a channelization effort that transformed the river into a deep, unshaded 56-mile canal. The channelization of the Kissimmee River alone drained 34,000 acres (13,800 hectares) of floodplains, wiping out 5 billion small fish and 6 billion shrimp.<sup>3</sup> Birds and vegetation also suffered. Not only were the spatial and temporal scales large in this restoration project, but three governors of Florida were involved in the initial stages, and subsequent governors were key to continued success in maintaining the partially restored system.

Another success story is the cleanup of the Thames River estuary in the United Kingdom. The Thames estuary fishery started to decline about 175 years ago. By the 1950s, the only fish able to survive in the most polluted reaches were eels. Between 1967 and December 1973, however, a total of 73 species were recorded, and isolated captures from December 1973 to March 1975 increased the total to 80. Improved waste

treatment and management probably accounted for much of the improved ecological conditions, which required the cooperation of numerous stakeholders and the balancing of conflicting values such as sewage treatment, water quality, fish and wildlife habitat restoration, navigation, and upland development.

### **Paying the Piper**

Garrett Hardin's classic paper, "The Tragedy of the Commons," published in *Science* magazine in 1968, illustrates the problem of protecting communally used lands from damage.<sup>4</sup> A few individuals may benefit substantially from overuse of the commons—by grazing too many cattle on it—but the costs of the damage and restoration are distributed over society as a whole. Unrestricted use of aquatic ecosystems is a ubiquitous phenomenon, and those who profit from abusing them, such as polluters who have used natural systems and lakes to carry off their wastes, generally evade paying for restoration.

The penalties of an unmanaged commons have been recognized for years, but the funds for correcting abuse through ecological restoration have been difficult to obtain.<sup>5</sup> It seems society is prepared to pay the cost of maintaining and restoring the technological infrastructure but is extremely reluctant to restore the ecological infrastructure. This mind-set is curious but understandable—pot-holes in highways are more easily observed than comparable damage to ecosystem integrity. Funds for "developing" natural systems—for example, displacing the biota with shopping malls, housing developments, and highways that shave a

few minutes of commuter time—have always been plentiful compared with the funding to restore ecosystem damage. What is especially lacking is the will to fund aquatic ecosystem restoration. If funds have not been available in the current era of global prosperity, the prospects of such funding seem dim during the economic downturn we are likely to face in the near future.

Reasons to restore aquatic ecosystems range from improving the quality of water for consumption, agriculture, and recreation to providing habitat for fish, wildlife, and endangered species. Though the popular press carries stories on the crisis of species extinction,<sup>6</sup> the general public is less aware that water for irrigation and other agricultural uses is becoming exceedingly scarce throughout the globe.<sup>7</sup>

Moreover, the implications for human health are great. Evidence is mounting that environmental contaminants are implicated in developmental and neurological damage to human offspring through exposure to toxins in wildlife, particularly top-predator populations in aquatic ecosystems.<sup>8</sup> As the global economy rapidly spreads, so too will industrial contaminants, and the human health effects almost certainly will snowball. The process of restoring aquatic ecosystems therefore should include reducing contaminants that affect human health and the environment.

Yet the literature on who should pay for ecological restoration is sparse. One study that summarized the literature on paying for ecological restoration devoted considerable attention to the methods for evaluating the costs and benefits of restoration.<sup>9</sup> Clearly,

many funding sources are possible, all of which can be used to some degree in almost any area. Due to a high degree of site specificity, however, only a few of the sources may be available at one site. In addition, water—particularly in riverine systems—is likely to cross a number of political boundaries, large and small, so restoration will require funding from several sources.

### **The Ticking Clock**

Human society is struggling with other issues that involve the commons and the biosphere.<sup>10</sup> Each year, for example, the U.S. Congress and the president find themselves in a standoff over peacekeeping funds, leading some to wonder whether time is running out for peacekeeping efforts.<sup>11</sup> One might also wonder if time is running out for ecological restoration.

Ecological restoration is primarily an ethical issue.<sup>12</sup> If humans damage the biosphere, shouldn't they accept the responsibility of making whatever restoration is possible? How do we persuade them to pay for restoration? The following items are potential building blocks for a rationale for ecosystem restoration.<sup>13</sup>

- Society must protect the environment and enhance the benefits that ecosystems provide.
- Society's practices, rather than its statements, are the best indications of its guiding beliefs about its relationship with the environment.
- Documenting the full cost of ecological restoration may well serve as the best deterrent to further ecological damage.
- Situating ecological restoration projects in each ecoregion, and preferably in each major area of the

country, will provide easily accessible demonstrations for local citizens; this visibility increases environmental and restoration literacy.

### **Setting Goals**

Unless the term *restoration* is clear, communicating goals to the general public is difficult. Goals should therefore be broad-based and measurable. The lack of stated goals is surprisingly common despite the obvious need for them in the attempts to restore ecological damage.

Goals might range from restoring habitat for an endangered species in a hot spring to restoring Siberia's Lake Baikal, the largest freshwater lake in the world. Each goal is reasonable but will require different parameters to achieve success. If the goals are not explicitly stated, measuring success is impossible.

Perhaps fear of the results of measuring success accounts for the curious reluctance to set goals. The National Research Council has proposed national goals for the restoration of rivers, lakes, and wetlands that are quite specific, setting the amount and percentage of aquatic restoration as well as a target date.<sup>14</sup> Examples include:

- Restoring 40,000 miles (64,000 kilometers, or 12 percent of the U.S. total) of river-riparian ecosystems by 2010.
- Restoring wetlands at a rate that offsets any further loss of wetlands and contributes to an overall gain of 10 million wetland acres (4 million hectares, or 10 percent of the wetland acres lost in the past 200 years) by the year 2010.

Government policymakers have been noticeably reluctant to discuss modifying or implementing these goals. If aquatic ecosystem

restoration is to proceed in a systematic and orderly fashion, explicit goal setting is essential. The news media and the general public need to be aware of goals, as well as progress toward achieving them, so others may emulate these efforts.

### **Quality Control Monitoring**

Monitoring is surveillance undertaken to ensure that previously established goals or quality-control conditions are being met.<sup>15</sup> A long-accepted practice in the field of ecotoxicology is to develop feedback loops that provide information about the condition of an ecosystem.<sup>16</sup> Surveys assessing the structure and function of aquatic communities that provide early warning of deleterious conditions are an illustrative example of the type of information gathered.<sup>17</sup>

Feedback loops are the norm in hospital intensive-care units, industrial product monitoring, and outer-space vehicles. Without them, corrective action is problematic. But these practices are not well established in restoration of aquatic ecosystems. Failure to develop feedback loops in the dynamic process of aquatic ecosystem restoration is a significant obstacle toward achieving long-term goals.

Ideally, restoration monitoring should be carried out for a specified period, at least until the ecosystem is self-maintaining.<sup>18</sup> Prudent management requires some quality control information, however, even after self-maintenance is achieved, to provide early warning of adverse changes.

Most complex systems have a certain amount of redundant information. For example, there may be a number of aquatic organisms present that process detritus or

perform other comparable functions, or a species of prey may have numerous predators. In one sense, this information is redundant; in another, it provides evidence on the number of backup components if one is lost.

The multiple confirming lines of evidence from this redundancy, however, reduce the probability of false positives and false negatives, thus justifying the added cost of the redundant information. A false negative would indicate the restoration was on track toward the designated goals when, in fact, it was not. A false positive would indicate that unacceptable quality conditions existed and the project was not on track when the deviation was due to normal variability or some other ecological attribute that had not been adequately documented. In both cases, the error is due to extrapolations from an inadequate information base. A more adequate, and more costly, base produces less erroneous information because information viewed as redundant can also be viewed as confirming.

Building redundant information into a restoration project helps ensure the project's reliability. Although the cost of adding redundancy can be significant, the cost of acting on inadequate or unreliable information is almost certain to be higher.

### **Living Legacy**

Every generation receives a natural and cultural legacy in trust from its ancestors and holds it in trust for its descendants.<sup>19</sup> Environmental law professor Edith Brown-Weiss stresses the need for intergenerational fairness in water resource use; she says that each generation should protect the in-

tegrity of its water resources for the next generation.<sup>20</sup> Hydrologist Luna Leopold also argues for ethos, equity, and fairness in water resource use.<sup>21</sup> And I have argued elsewhere that ecological restoration is a major component of sustainable use of the planet.<sup>22</sup>

Not everyone is happy with the concept of ecological restoration, however. Some have criticized it as an unethical and immoral attempt to substitute "fake" natural systems for nature. Philosopher Eric Katz, for instance, deplors ecological restoration as an unwarranted intervention in natural systems and a form of human domination.<sup>23</sup> He further argues that ecological restoration based on functional attributes destroys the ontological identity of the area being restored.<sup>24</sup> Philosopher Robert Elliot has even condemned perfect restoration as a morally wrong process that replaces "real" nature with a "fake."<sup>25</sup> These critics propose leaving nature to develop as it chooses rather than as humans choose.

Conservation biologist Michael Soule asserts that nature is now assaulted by human, physical development as well as covert ideological and social actions.<sup>26</sup>

The debate is ongoing and is unlikely to be settled anytime soon.

### **Human Touch**

Since much of the damage to aquatic resources was inflicted, intentionally or not, by humans, humans should be responsible for helping restore ecosystems to a healthy state. This is not just an ethical or esthetic stand, however; it is also an economic one. Restoration benefits people as well as biota. From a sustainability standpoint, ecological restoration of

damaged aquatic ecosystems makes them more suitable for colonization and habitation by a greater variety of organisms than in their degraded state. Successful restoration enhances both reliability and abundance of ecosystem services essential to both nature and human society. The natural legacy for future generations will be more desirable if damaged ecosystems and anthropogenic artifacts—such as shopping malls, highways, and urban sprawl—are replaced, to the degree possible, with naturalistic assemblages of plants and animals.

Restoring aquatic ecosystems will normalize the hydrologic cycle to the benefit of both aquatic creatures and human society.

Finally, ecological restoration demonstrates an ethical responsibility for anthropogenic damage. It is indeed a pity the damage occurred, but making the ecosystem acceptable to its former inhabitants is preferable to neglect.

Most people, especially those who value recreation in natural systems, hope for a better quality of life. Ensuring quality of life demands that the rate of ecological restoration must exceed the rate at which ecological damage occurs. This is especially true because damage and restoration often occur at different temporal and spatial scales. An accidental spill of a hazardous material can severely damage an aquatic ecosystem in minutes or hours, but restoration to an approximation of its pre-disturbance condition can take years or decades.

Sustainable use of the planet requires that ecological damage be prevented whenever possible and that it be restored when damage occurs. We must protect the

planet's ecological life-support system. If we can ensure that the rate of restoration of ecosystems exceeds the rate of damage, future generations will hold us in their debt. ■

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# Endangered Economies

*An alternative approach to compliance with the Endangered Species Act is restoring endangered fish in the Colorado and San Juan Rivers.*

BY JAMES V. HANSEN

In October 2000, Congress passed and sent to the president a bill to authorize federal cost-sharing for implementation of recovery programs targeting endangered fish.<sup>1</sup> The bill addressed the upper Colorado River and San Juan River basins in portions of Utah, Colorado, New Mexico, and Wyoming. I introduced this bill in the House of Representatives, with bipartisan co-sponsorship from members of the House from all four states. The House Resources Committee approved the bill, also with strong bipartisan support. There was strong bipartisan support in the Senate as well.

The legislation had the strong support of the four states involved as well as power users, water us-

ers, environmentalists, and the Clinton administration.<sup>2</sup> While HR 2348 did not amend the Endangered Species Act in any way, such widespread support for a bill addressing the needs of endangered species is unprecedented. The broad support for the bill resulted from the manner in which these recovery programs work on a cooperative basis to achieve the goals of the Endangered Species Act and the goals of numerous and diverse interests.

## **Particulars of the Act**

The Endangered Species Act was passed almost unanimously by Congress in 1973. The purposes of the act are to conserve ecosystems that threatened and endangered species depend upon, to conserve endangered and threatened

species, and to comply with treaties and conventions entered into by the United States regarding endangered and threatened species. The act declares "that all federal departments and agencies shall seek to conserve endangered and threatened species and to utilize their authorities in furtherance of the purposes of this Act."

Later amendments declared "that federal agencies shall cooperate with state and local agencies to resolve water resource issues in concert with the conservation of endangered species."

The key provisions that implement the act are Section 4, "Determination of Endangered Species and Threatened Species," which sets forth procedures for identifying and listing endangered and threatened species; Section 7, "Interagency Cooperation;" Section 9, "Prohibitive Acts;" and Section 10, "Exceptions."

Section 4 specifies the legal requirements and procedures for identifying and listing species, including responses to citizen petitions to list species. Once species are listed, all of the other provisions of the act come into play. Section 4 also requires development and implementation of recovery plans for listed species and requires a review every five years of the status of the species to determine if it should be removed from the list or should be changed in status with respect to being endangered or threatened.

The primary means of implementing the Endangered Species Act has been through Section 7, "Interagency Cooperation." This section requires the secretaries of the Interior and Commerce to utilize all programs under their purview in furtherance of the purposes

of this act. In addition, the act requires that “all other federal agencies shall...utilize their authorities in furtherance of the purposes of this Act.” Section 7 also requires each federal agency to consult with the secretary to “insure that any action authorized, funded, or carried out by such agency, is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification” of critical habitat of the species.

Section 9, “Prohibitive Acts,” makes unlawful a number of activities that affect endangered species, including the “taking” of any such species, without a permit. Section 10, “Exceptions,” authorizes the secretary to issue permits to legalize acts prohibited by Section 9, “if such taking is incidental to, and not the purpose of, carrying out of otherwise lawful activity.” Essentially, Section 10 allows the secretary to authorize takings if appropriate mitigation can be provided. For instance, constructing a dam that would destroy critical habitat of an endangered species, and therefore would be illegal under Section 9, might be permitted under Section 10 if the endangered species affected could be successfully transplanted to a new area where the species is not found. Section 10 also provides the legal authority for the numerous plans to conserve habitat.

### **Tortured Implementation**

In 1973, no member of Congress could envision application of the Endangered Species Act as it has evolved. The congressional vision of “endangered species” was largely limited to eagles, whooping cranes, and perhaps, grizzly

bears. There was no anticipation that the Endangered Species Act would be applied to species of flies, mussels, snails, or snakes. There was no vision that the recovery and delisting of species would be an extremely rare event. There was no vision that approximately 1,000 species would be listed as endangered within a quarter of a century, with the list still growing and no foreseeable limits on the number of species that might be listed. There was no expectation that practically every county in the western United States would either contain an endangered species or be affected by a listing.

The number of species listed, however, is not the most remarkable aspect of implementation of the Endangered Species Act. Most striking are those actions that take place after species are listed. If an endangered species resides temporarily or permanently on a person’s land, the federal government can place restrictions on the use of that land under Section 9 of the Act. In essence, the federal government acquires an ownership interest in private property through its ability to restrict actions of the owner.

In the *Sweet Home* decision,<sup>3</sup> the Supreme Court upheld the secretary of the Interior’s position that “taking” under the Endangered Species Act includes “harm,” as stated in the act, and that harm includes “significant habitat modification or degradation,” as interpreted by the U.S. Fish and Wildlife Service.

This means that anyone adversely modifying the habitat of an endangered species, even on one’s own property, is committing an illegal act. The practical effects are either restrictions on actions on private property or requirements

that anyone proposing such actions must obtain a permit from the Fish and Wildlife Service. Acquiring a permit often means agreeing to mitigation requirements. Mitigation requirements are normally the responsibility of the landowner and constitute an additional expense, either in land or money.

The legal act of diversion of water from a stream in any state can be made illegal if there are endangered species in the stream. If endangered species—adult, young, or larvae stages—enter the diversion, this constitutes a taking under the Endangered Species Act and is illegal without a permit. Theoretically, the driver of an automobile with an endangered fly on the windshield is in violation of the Endangered Species Act, unless some entity has obtained a permit for such a taking.

A literal reading of Section 7 implies that it only applies to actions by federal agencies, and this is still commonly misunderstood by many. But the fact remains, federal actions include permitting, funding, or otherwise allowing activities to take place that may affect endangered species. This provision results in the broad application of the Endangered Species Act to numerous land and water management activities in the West.

Practically every major river basin in the West includes threatened or endangered fish or other aquatic species. The issuance of a permit for a dam, diversion works, or other construction in or near a river or wetlands triggers Endangered Species Act compliance. This provision is coupled with a broad definition of impacts to endangered species.

The Fish and Wildlife Service,

for instance, holds that the depletion of water anywhere in the Upper Colorado River Basin will adversely affect the four endangered fish species that reside in the lower, warm-water reaches of the Upper Basin rivers. As a consequence, depletion activities far upstream of the habitat are considered to "jeopardize" the endangered species, even though endangered species habitat may be hundreds of miles downstream.

The application of the act has been expanded, and it now encompasses grazing permits issued by federal agencies to individual ranchers, federally funded conservation activities on farms, and practically all activities on lands managed by any federal agencies, including the Bureau of Land Management, the U.S. Forest Service, and the Department of Defense. The act is applied to contracts between the Bureau of Reclamation and individual water users that address water from federal projects, the annual operation of federal water and power projects, and hydroelectric power generation operations that change the flows in rivers and streams. Moreover, permits issued by the Federal Energy Regulatory Commission are subject to Endangered Species Act compliance. Almost any project to benefit American Indians on their own reservations is also subject to Endangered Species Act compliance and restrictions, since these are all normally a function of some federal activity. The vast federal land ownership in the western states also triggers application of the Endangered Species Act to countless activities.

Clearly, the Endangered Species Act can affect water users throughout the western United States,

ranging from the individual farmer, rancher, or irrigator to the largest municipalities and industries. Water development activities by American Indians are equally subject to the provisions of the Endangered Species Act.

### **Economics and the Act**

The Endangered Species Act, as written and in practice, is virtually devoid of economic considerations. In this way it is unique in American law. Listing of species as threatened or endangered requires no consideration of the resultant economic impacts. The Fish and Wildlife Service has routinely concluded that listing a species is not subject to provision of the National Environmental Policy Act, a federal act designed to disclose the impacts of federal actions on the human environment. As a result, there is no economic or environmental review of the impacts of listing endangered species.

Critical habitat designation is subject to economic impact analysis, but these economic analyses routinely conclude that critical habitat designation does not have a significant economic impact in itself or that the impact is minimal on a national or regional scale. Thus, the federal government evades any substantive analysis of economic or environmental impacts for implementing the act.

This lax approach to economic analysis occurs despite the drastic impacts of the act in some areas and on some economic sectors. For significant examples in the Pacific Northwest, you need look no further than the spotted owl and several species of endangered salmon. In fiscal year 1997, reported federal and state expenditures for the three species of Columbia Basin

salmon totaled \$72.2 million.<sup>4</sup> Expenditures for these species have occurred in the past and will continue into the foreseeable future. The economic effects on the timber industry and associated communities and on hydroelectric power production and costs are significant.

There was a previous agreement that the Bonneville Power Authority (BPA), which generates hydroelectric power in the Pacific Northwest, would expend no more than \$435 million per year, on average, on endangered species and other fish and wildlife purposes. These costs are passed on to BPA power customers. Of this total \$183 million would result from lost revenues from power generation in order to meet flow requirements for fish, and to purchase power resulting from lost generation capacity. BPA is now operating under a biological opinion recently issued by the National Marine Fisheries Service. BPA estimates it may have to spend as much as \$2.0 billion to purchase power in 2001, while operating under the biological opinion issued by National Marine Fisheries Service.<sup>5</sup>

Federal regulations to implement Section 7, "Interagency Cooperation," state that "reasonable and prudent alternatives" must be "economically and technologically feasible." Reasonable and prudent alternatives are alternative actions that can be implemented to avoid the likelihood of jeopardizing the listed species or the destruction or adverse modification of critical habitat. In other words, reasonable and prudent alternatives are mitigation measures for impacts on endangered species, resulting from actions of federal agencies.

The determination of what is

“economically and technologically feasible” apparently is made by the agency having oversight responsibilities, but this has not prevented the implementation of “reasonable and prudent alternatives” that have had drastic economic effects, such as those being imposed on federal hydroelectric power operations in the Pacific Northwest. There is no evidence that the criterion that reasonable and prudent alternatives be “economically” feasible has any meaning in the application of the Endangered Species Act.

### **Endangered Economic Health**

The Endangered Species Act is the most powerful environmental law enacted by Congress. In reality, any federal agency action affecting a listed species is subordinated to the act. Unprecedented discretion is given the two agencies implementing the act, the Fish and Wildlife Service and the National Marine Fisheries Service. There are virtually no economic constraints in implementing the act.

One of the great failures in implementation of the Endangered Species Act is the emphasis on Sections 7 and 9, which provide for enforcement of the act against citizens otherwise engaged in lawful activities. While conservation and recovery is the stated goal of the act, the emphasis is on enforcement. In fact, the cost of recovery has not even been estimated for hundreds of listed species. New species are being listed without any indication of the feasibility of recovery, much less the cost of recovery and delisting of those species.

The Endangered Species Act was last reauthorized in 1987 for a period of five years. It was due for reauthorization in 1992. Dur-

ing the last nine years, several bills have been introduced in both the House and the Senate to reauthorize the act. Some of these bills have attempted to address the problems described above. Others have attempted to reinforce the existing methods of implementing the act or to make it even more stringent. Few of these bills passed Senate or House committees, and none was enacted into law. There is no consensus by a congressional majority on what changes need to be made to the act. As a result, the existing act remains the law of the land.

### **Chronology of Compromise**

The Upper Colorado River Basin, which is the watershed upstream of Glen Canyon Dam, includes more than 108,000 square miles (280,000 square kilometers) of drainage and thousands of miles of rivers and streams. It also includes 800 miles (1,300 kilometers) of designated critical habitat for four endangered fish species.

Water development and use in the basin supports irrigated agriculture, urban development, recreation, fisheries, wildlife, and a variety of industries. Transfer of water out of the basin also supplies municipal water for Salt Lake City, Cheyenne, Denver, Colorado Springs, Albuquerque, and other urban areas in Utah, New Mexico, and Colorado.

When the Endangered Species Act was passed in 1973, the Colorado squawfish—now the Colorado pikeminnow—and the humpback chub were “grandfathered” as original listed endangered species. Two other Colorado River basin species, the razorback sucker and the bonytail, were later added to the endangered species list. In the

late 1970s, the Bureau of Reclamation began “consulting” with the Fish and Wildlife Service on the impacts of water projects on endangered species, as required by the Endangered Species Act.

Since that time, the Fish and Wildlife Service has uniformly held that water project depletions anywhere in the Upper Colorado River Basin, including those depletions upstream of pertinent habitat, “jeopardize” the endangered fish. In the early 1980s, the Endangered Species Act was applied to nonfederal projects. In the interim, water users and the Upper Basin states began to more fully understand the implications of the Endangered Species Act; a decision of the U.S. Supreme Court brought construction of Tellico Dam—a project of the Tennessee Valley Authority—to a complete halt due to potential impacts on the snail darter, an endangered species.

In July 1983, the Fish and Wildlife Service developed a draft report stating that the only way for water projects in the Upper Colorado River Basin to avoid jeopardizing endangered fish species was to replace all depletions on a one-for-one basis. New projects would have to double storage capacity and release one-half of the depletion to the stream to offset the other one-half being used. This requirement would have made future water development infeasible. It would have deprived the Upper Basin states of water entitlements provided for under interstate compacts that had been ratified by Congress.

■ **Colorado Water Congress Special Project.** The draft report got the attention of the Upper Basin states and Upper Basin water us-

ers. In December 1983, water users in Colorado and Utah asked the Colorado Water Congress, a statewide water users organization based in Colorado, to form the Colorado Water Congress Special Project on Threatened and Endangered Species.

The Colorado Water Congress Special Project's objectives were to resolve potential conflicts with the Endangered Species Act in a manner that respected state water law, recognized interstate water compacts, and equitably distributed the cost of any solution. Negotiations to resolve the potential conflicts began in 1984 and involved the Fish and Wildlife Service; the Bureau of Reclamation; the states of Colorado, Wyoming, and Utah; the Colorado Water Congress Special Project; environmentalists; and, later, the Western Area Power Administration.

In May 1985, the Colorado Water Congress Special Project proposed that the endangered fish species be recovered and delisted. The special project also proposed that actions taken to recover the species be used as mitigation to offset the effects of water development and management activities under the Endangered Species Act. The water users' rationale was that the only way to solve the problem in the long term was to recover and delist the species. Otherwise, there would be an endless series of "consultations" and, eventually, limitations would be placed upon depletions in the Upper Colorado River Basin. The special project proposal was followed by two additional years of intense, but successful, negotiation.

■ **Recovery program.** In January 1988, the secretary of the Interior, the administrator of the Western

Area Power Administration, and the governors of Colorado, Wyoming, and Utah signed a cooperative agreement establishing the Upper Colorado River Endangered Fish Recovery Program. The objective of this program is to recover four endangered fish species in the Upper Colorado River Basin while water development proceeds in compliance with the Endangered Species Act, state law, interstate compacts, and Supreme Court decrees allocating water among the states.

A governing committee was established that includes water users, environmentalists, and representatives of the Fish and Wildlife Service, the Bureau of Reclamation, the Western Area Power Administration, and the states of Colorado, Utah, and Wyoming. The governing committee operates by unanimous consensus.

Technical committees were established with the same institutional representation. The Colorado River Energy Distributors Association and the National Park Service were added as voting members in September 2000. The Colorado River Energy Distributors Association represents 130 organizations in six states that purchase power from federal hydroelectric projects at Bureau of Reclamation dams in the Colorado River Basin.

#### **Dearth of Information**

In 1989, very little was known about the biology and habitat requirements of the endangered fish in the Colorado River Basin. Less was known about the actual numbers of fish present. The information available at that time indicated that the numbers of endangered fish had declined sharply

over the decades; the bonytail was virtually extinct in the Upper Basin, and the razorback sucker was continuing to decline and near extinction. The recovery program initiated wide-ranging research and monitoring programs to fill the huge information gaps regarding the needs of these species and to establish the actual numbers present. The intent of the research was to lay the groundwork for management actions to recover the endangered fish.

Major recovery program activities have been in the areas of habitat restoration and instream flow protection, nonnative fish management, stocking, propagation and genetics management, research and monitoring, information and education, and the associated program management. To date, flooded bottomlands habitat has been acquired for the endangered species. Propagation facilities have been constructed. Major stocking programs are underway. Water needed for endangered fish habitat is being acquired in accordance with state law.<sup>6</sup> Instream flows for endangered fish are being protected under state law. Reservoir operations are being modified consistent with state law to benefit endangered species downstream. Improvements in irrigation systems are being constructed, with the conserved water being used in accordance with state law to enhance flows for endangered fish.

From 1989 through 2000, a total of \$81.7 million has been expended on the Upper Basin recovery program. These funds include \$49.7 million in congressional appropriations to the Bureau of Reclamation and the Fish and Wildlife Service; power revenues of \$22.9 million; \$7.2 mil-

lion from Colorado, Wyoming, and Utah; and \$1.9 million from water users.

The recovery program provides mitigation for impacts of water projects on the endangered fish. In the 12-year history of the program, the Fish and Wildlife Service has found more than 600 water projects, depleting 1,700,000 acre-feet (2 billion cubic meters) per year, to be in compliance with the Endangered Species Act. Not one lawsuit challenging these findings has been filed by any party.

The San Juan River Basin Recovery Implementation Program has been on a similar track. The program was instituted in 1992 to provide for recovery of two of the four endangered species, the pikeminnow and razorback sucker. The San Juan basin covers portions of southwestern Colorado, southeastern Utah, and northwestern New Mexico.

Since inception of the San Juan recovery program, about \$12 million has been expended. The program provides Endangered Species Act compliance for approximately 800,000 acre-feet per year of depletions in the San Juan River basin, including depletions for water projects benefitting the Navajo Nation, Ute Mountain Ute Tribe, Southern Ute Tribe, and Jicarilla Apache Tribe.

### **Federal Authorizing Legislation**

In the mid-1990s, participants in the Upper Colorado River Endangered Fish Recovery Program began requesting congressional appropriations in the range of \$5 million to \$7 million per year to develop the capital facilities—hatcheries, fish passages, reservoir modifications—needed to recover the fish. Congress asked program

participants to define overall needs and to come up with additional cost sharing to implement these projects. These questions also applied to the San Juan River Basin Recovery Implementation Program.

As a result, HR 2348 was introduced in the House in 1999 to provide continued funding for the Upper Colorado and San Juan recovery programs. The bill authorizes capital project funding of \$46 million in congressionally appropriated funds and recognizes \$17 million in funds contributed by the four Upper Basin states and \$17 million contributed by power users benefitting from the hydroelectric projects in the Colorado River basin. In addition, the legislation recognizes in-kind contributions of \$15 million by power users—in the form of lost power that hydroelectric projects would have generated if it had not been for the fish—and \$5 million by the Colorado River Water Conservation District for water to benefit endangered fish from Wolford Mountain Reservoir. These funds will be used to continue operation and maintenance of the capital projects and to continue monitoring fish populations. Funding may be continued after that point for those purposes, but only after Congress reviews the recovery programs' accomplishments.

### **Power Generators Ante up**

Revenues from the hydroelectric power projects have played a significant role in financing the Upper Basin Recovery Program to date and will play a significant role in the future. Moreover, power users have continued to support legislation authorizing use of power revenues, for a number of reasons.

First, there is a cap on the amount of money that will be devoted to the program. Second, the manner in which the power revenues will be applied does not affect rates. Third, Congress receives reports on the recovery program on an annual basis as congressional appropriations are requested. And fourth, there will be an overall congressional review of any continued expenditures of power revenues in 2010. The checks and balances on use of power revenues provided in HR 2348 stand in stark contrast to the apparently unlimited use of power revenues to support Endangered Species Act activities in the Columbia River Basin.

The House of Representatives passed funding legislation for the bill in July 2000. The Senate passed the measure in October, and the bill was signed into law on October 30, 2000. This legislation was made possible by strong support from all recovery program participants, including the administration, environmentalists, water users, power users, and the Upper Basin states. The federal funding legislation will ensure continued funding for the recovery programs in the Upper Colorado River and San Juan River basins with congressional oversight.

### **Program Successes**

The recovery implementation programs are working for water users in Utah, Colorado, Wyoming, and New Mexico. Endangered Species Act compliance has been provided on 2.5 million acre-feet per year of depletions, with no litigation. Endangered fish are on the road to recovery. There has been no taking of water by the Fish and Wildlife Service for endangered species. Instead, water for the species is

being provided in accordance with state law and interstate compacts.

Equitable and mutually agreeable funding arrangements were negotiated by the programs' participants. All the participants have made long-term commitments to the recovery programs and have supported legislation to provide continued funding. A broad range of activities is being carried out to recover the endangered fish, and the endangered fish are beginning to respond to those actions. Colorado pikeminnow populations are increasing. The razorback sucker was near extinction. Stocked razorback sucker are now appearing at spawning locations. Humpback chub populations are stable. Bonytail are being reintroduced. The long-term prognosis is that the endangered fish will be recovered in the foreseeable future. One

major benefit of the programs is that delisting is a realistic goal.

The Upper Basin and San Juan recovery programs are not without flaws, but they are achieving the goals of the Endangered Species Act while avoiding conflicts with other federal and state laws. This is a truly remarkable achievement. Indeed, Congress and the federal agencies could benefit by considering these programs as examples of how the Endangered Species Act should be implemented. ■

*The Honorable James V. Hansen is a member of the United States Congress. He is the representative of Utah's First District.<sup>7</sup>*

#### NOTES

1. Enacted as P.L. 106-392.
2. S. 2239, introduced by Senator Allard

(R-CO), is the corresponding Senate bill.

3. See *Secretary of the Interior v. Sweet Home Chapter of Communities for a Great Oregon*, 515 U.S. 687 (1995).

4. Federal and State Species Expenditures, Fiscal Year 1997; Bruce Babbitt, Secretary of the Interior, August 30, 1999.

5. Personal communication, Mark Walker, Director of Public Affairs, Northwest Power Planning Council.

6. There is no condemnation of water rights under the program.

7. The author wishes to recognize the contributions of Tom Pitts and Allen Freemyer to the development of this article. Tom Pitts, principal of Water Consult, Engineering and Planning Consultants, Loveland, Colorado, represents Utah, New Mexico, Colorado, and Wyoming water users on the Upper Basin and San Juan recovery implementation programs. Allen Freemyer is Majority Staff Director, National Parks and Public Lands Subcommittee, House Resources Committee, U.S. House of Representatives.

# Supply and Demand

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# Liquid Currency

**T**hough most of us don't flinch at the price of a bottle of Perrier, consumers would be shocked to learn the real cost of water for domestic, industrial, and agricultural uses. But the global water squeeze may force us to appreciate the real value of water, a natural resource more essential than gold, oil, or timber.

While the global supply of water is constant, the supply available for consumption is growing scarce. Kenneth D. Frederick with Resources for the Future says we need to use economic principles in allocating supplies. Water marketing has a promising future. California, for example, has created an emergency water bank that allows farmers to idle land during drought and sell to the expanding urban market. The uncertain future under a global-warming scenario lends a sense of urgency to efforts to encourage voluntary exchanges of water through markets, Frederick says.

Around the world, water supplies are dwindling, in part from contamination by municipal, industrial, and agricultural effluents. In the United States, targeting specific facilities and enforcing regulation of the Clean Water Act of 1972 have proven expensive, and most agricultural sources of pollution, such as large animal feeding op-

erations, have escaped regulation. Suzie Greenhalgh and Paul Faeth with the World Resources Institute say that recent experiments in water quality trading have proven cost-effective.

As we enter an era of market trading, one unsolved mystery is how to integrate the benefits of markets with environmental objectives. Till now, we've gone about environmental protection in the old-fashioned way: throwing money at it, says Dan Tarlock at Chicago-Trent College of Law.

A better model may be underway Down Under. Australia's Murray-Darling River has been severely degraded, especially from salination due to diversions and dams. The Murray-Darling Commission, composed of federal, state, environmental, and private stakeholders, imposes yearly limits, or caps, on diversions from the basin. Under the pilot trading program, diverters must gain the approval of licensing authorities in each state, and all transfers must meet environmental standards. The Murray-Darling experiment proves that long-term environmental goals are consistent with sustainable economic development, Tarlock says.

In the spring of 2000, while Atlanta continued to grapple with a prolonged drought and the state of Georgia turned a thirsty eye north, Tennessee quietly conducted a preemptive strike to protect its waters from interstate raids. In May, the Tennessee legislature

passed a bill to protect its waters from new diversions outside 10 designated water basins. While threats from out of state were part of the rationale for protective legislation, the bill also maintains the integrity of the water basins for planning purposes. David Feldman at the University of Tennessee says that a key bargaining point for the business community was to ensure that permitting costs and economic burdens would be nominal.

Statewide initiatives may be only a thumb in the dike, however. Nationwide, water problems are staggering: flood losses of over \$4 billion annually, wetland losses of 50 percent, pollution from agricultural runoff, and failing water and sewer systems. Oregon's Earl Blumenauer, a congressman from Portland, says certain federal programs, including the national flood insurance program, are costly and counterproductive. Blumenauer has introduced an initiative to build on the success in the transportation sector of the Intermodal Surface Transportation Efficiency Act. A "Water ISTEA" would allow regional rather than local planning, provide flexibility for local communities to decide the kinds of projects that suit their needs, and encourage meaningful citizen participation.

*The Editors*



# Water Marketing: Obstacles and Opportunities

*New market-based management strategies may prompt conservation and lead to higher-value uses of water resources.*

BY KENNETH D. FREDERICK

**F**reshwater is a scarce and often threatened resource throughout much of the United States, but particularly in the arid West. Supplies are being depleted or degraded by unsustainable rates of groundwater use, contamination, and damage to aquatic ecosystems. Meanwhile, demands for water are rising with an expanding population, higher incomes, and a growing appreciation for the services and amenities provided by streams, lakes, and other aquatic resources. But the options for increasing supplies are expensive relative to current water prices and are often environmentally damaging.

Providing for increasing water demands requires changes in how water

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has traditionally been managed and allocated among competing uses. There is a growing consensus that greater reliance on economic principles in managing and allocating water is critical for more efficient and sustainable use.

More than a quarter century

ago, the U.S. National Water Commission's *Final Report to the President and to the Congress* made a strong case for facilitating voluntary water transfers to promote a more-efficient allocation of scarce water resources and to curb the perceived need for additional wa-

ter supply projects.<sup>1</sup> In 1992, the International Conference on Water and the Environment in Dublin and the Earth Summit in Rio both endorsed viewing water as an economic good. Introducing economic incentives was also one of the core recommendations of the World Bank policy paper on *Water Resource Management* prepared that same year.<sup>2</sup>

In 2000, the World Commission on Water for the 21st Century concluded that we are on a path toward a water crisis and that business as usual is unsustainable.<sup>3</sup> The commission's proposals for changing course include recognizing that water is a scarce resource and that we need to manage it accordingly.

## Water Markets

**M**arkets and prices play a role in allocation of resources among competing uses, and they provide incentives to conserve and invest in new supplies. In a competitive economy, price adjustments and market transfers keep supply and demand in balance. Prices rise when demand increases faster than supply. Higher prices provide incentives to use less, to produce more, and to develop and adopt technologies that conserve use and increase output. Markets enable resources to move from lower to higher-value uses as conditions change. For example, water traditionally used for irrigation may be more valuable as a municipal water source as the demands of a nearby urban center increase.

Tradable water rights potentially can encourage conservation and a more economically efficient allocation of scarce water resources. Currently, water is underpriced and often allocated based on institutions established when water was not considered to be a scarce resource. Users pay nothing for the water itself. Municipal and industrial users typically pay a fee reflecting the costs of storing, delivering, and treating water supplies. But even these costs are likely to be subsidized for irrigation, which commonly represents a region's largest water use. Without an opportunity to sell unused supplies, irrigators have little incentive to conserve water. With the introduction of tradable water rights, however, users value water in terms of its opportunity cost—the value they could get by selling water—rather than at the subsidized price they pay for it.

In spite of their potential benefits and growing popularity, mar-

ket forces have been slow to adapt to the reality of water scarcity. Efficient markets require well-defined, transferable property rights, and the full costs and benefits of a transfer must be borne by the buyers and sellers. Both the nature of the resource and the institutions that manage and allocate water can make it difficult to meet these conditions.

ownership of land. They continue to provide the basis of water law in many areas, including some arid Moslem and humid European countries and the eastern United States. These rights are poorly defined because shortages are shared by all riparian owners and use is subject to regulatory or judicial interpretation as to what is reasonable or might unduly inconvenience others.

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## Market forces have been slow to adapt to the reality of water scarcity.

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### Obstacles

**T**he variability of water supplies in time and space creates problems for establishing clear property rights. Driven by energy from the sun, water constantly evaporates from seas, lakes, and streams or transpires from plants, entering the atmosphere, then returning to earth through precipitation. Precipitation that is not quickly evaporated or transpired back to the atmosphere is the source of a region's renewable water supplies. This water flows into lakes, rivers, groundwater reservoirs, and eventually the ocean, unless it is first withdrawn for use.

Three basic systems—riparian rights, prior appropriation rights, and public permits—have developed for establishing rights to this water.

**Riparian rights.** The common law system of riparian rights gives owners of the lands bordering a water body use of the water in ways that do not unduly inconvenience other riparian owners. Riparian rights have origins in the earliest legal systems establishing private

nience others. Moreover, riparian rights are not directly marketable because they are attached to the land and use is restricted to those lands.

**Appropriative rights.** Constraints on transferring water to non-riparian lands and uncertainties such as how much water a riparian owner can use are obstacles to applying riparian rights in areas where streams are fewer and flows are smaller and less reliable. Consequently, in the arid and semi-arid western United States, riparian rights were abandoned in favor of water rights based on prior appropriation. Prior appropriation rights, which have been adapted by all 17 western states, have three principal features:

- Water rights are established by withdrawing water from its natural source and putting it to a beneficial use, such as irrigation. Unlike the owner of riparian rights, the party appropriating water does not have to be a riparian landowner, and the water does not have to be used on riparian lands.
- During periods of shortage, water is allocated according to the

principle of “first in time, first in right.” Thus, junior appropriators receive no water until senior appropriators—those with the oldest rights—have received their full allotment.

■ Failure to use water for some period of time results in loss of the right. This provision creates a use-it-or-lose-it incentive, encouraging withdrawal even when the water

place or use to another will commonly affect third parties—those other than the buyer and seller. When a farmer sells—in effect, transfers—water to a city, the economic base of the water-exporting community may decline. And when a transfer alters the quantity of water in a stream, other stream users are likely to be affected. Indeed, changes in flow affect the

ignored. On the other side are the more-recently empowered stakeholders armed with legislation designed to protect and restore environmental and recreational uses.

While domestic, industrial, and agricultural users may compete for the water diverted from streams and reservoirs, all three groups vie with environmentalists and recreationists over the amount that can be withdrawn. Conflicts also arise over the priority that dam operators give to flood control, water supplies, hydropower production, fish habitat, and recreational opportunities. Without markets and prices to guide allocation of water and guide dam and reservoir management, conflicts are often played out in the courts or administrative proceedings.

Groundwater initially was treated as a resource that landowners could capture at will. But groundwater is often a common property resource that flows from one property to another until captured for use. Pumping can adversely affect third parties. One party’s pumping can reduce the water available to neighboring water users, forcing them to pump from greater depths and lowering their well yields. Third parties may also be harmed if groundwater use reduces surface flows, causes salt-water intrusion into an aquifer, or results in the collapse of lands above underground aquifers that have been at least partially drained.

The emergence of such impacts, along with improved knowledge of the links between ground and surface water, have led to restrictions on groundwater use. In the western United States, for instance, most states have adopted some form of a permit system for groundwater. But even in states lacking a permit system—such as Texas, which contin-

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## As supplies become scarcer, governments are

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### assuming a more active role in controlling

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#### water use.

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contributes little if any value to the user.

Appropriative rights encourage the depletion of waters in a stream. Until recently, such instream flows lacked protection under state water laws. Unlike riparian rights, appropriative rights can be transferable, but sales are commonly restricted as to how and where water can be used.

**Public permits.** Riparian and appropriative water rights initially were acquired without state interference. But as supplies become scarcer, governments are assuming a more active role in controlling water use. Some form of a permit system now governs use of at least some water in virtually every country.<sup>4</sup>

In principle, water permits can be auctioned by governments and bought and sold in private markets. In practice, however, permits are usually free, and transfers are limited by the nature of the right as well as by the infrastructure available to store and transport water.

Transferring water from one

amenities and recreational opportunities that rivers and lakes provide, as well as the individuals who enjoy them. Generally, these water services are public goods that are not marketed, because the public cannot be excluded from freely enjoying them. Thus when marketing water, the private sector tends to ignore the impacts of water transfers on the public goods the waters produce. Similarly, polluters underinvest in waste reduction and treatment when the costs of using water bodies for waste disposal are borne by society rather than the individual polluter.

During the past three decades, water-related investments and legislation in the United States have been driven largely by a desire to protect the resource and the public benefits it provides. The resulting environmental legislation and regulations have contributed to uncertainties over water rights. On one side are the traditional users with rights established when water was treated as a free resource and environmental impacts were

ues to grant landowners unrestricted rights to pump groundwater without liability for damages inflicted on others—landowners overlying a defined aquifer may voluntarily form a conservation district to regulate wells.

### Opportunities

**T**he absence of markets and market-based prices to allocate scarce supplies and guide water managers has resulted in large differences in the value of water among alternative uses. For example, most of the water rights in the western United States are held by farmers and irrigation districts, which pay only the modest cost of having water delivered to their farms. As a result, large quantities of water are applied liberally to relatively low-value crops. In some cases, simply leaving more water in the river to provide hydropower, recreation, and fish and wildlife habitat might increase the total value of the water to society. Similarly, selling water to urban areas that otherwise would invest in costly and often environmentally damaging water-supply projects might boost water values by an order of magnitude or more in some cases.<sup>5</sup>

Large differences in the value of water among alternative uses provide powerful incentives to overcome obstacles to transfers. As a result, water marketing is becoming common and increasingly innovative in several countries. A variety of market arrangements have emerged in the western United States to accommodate and respond to short-term fluctuations in supply and demand stemming from climate variability or other factors. These include leases, op-

tions to purchase water during dry periods, and water banking. The temporary nature of such transfers blunts a principal third-party concern that a transfer will undermine the economic and social viability of the water-exporting area.

Farmers with senior appropriative rights who grow annual crops might profit by selling an option to use some of their water during

objective of a water bank is to bring together those who want to purchase water with those who are interested in selling their entitlements.

The bank provides several key functions. It determines which water use entitlements may be banked and the quantity of water associated with each entitlement. It determines who can rent or buy

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## Water marketing is becoming common and

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## increasingly innovative in several countries.

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a drought and leaving some or all of their fields fallow. Growers threatened with the loss of long-term investments in orchards, or cities facing rationing, are able to more than compensate these farmers for losses incurred from temporarily leaving some of their lands fallow.

Such transfers among farmers within the same irrigation district are common and often relatively easy to arrange. But cities seeking to transfer water away from an irrigation district are likely to encounter greater institutional obstacles and financial costs.

### Water Banks

**W**ater banks represent one solution to these obstacles. Water banks are designed to facilitate water transfers in response to short-term changes in supply and demand conditions. They enable the owner of a permanent water right to sell all or part of one year's entitlement. Thus, the entitlement is, in effect, leased or rented but not permanently transferred. The primary

water, and it sets the rental rules. The bank may also determine how much water can be transferred without injury to third parties. Once the rules are established, the bank operates like a broker, accepting valid water use entitlements for deposit and making them available to those hoping to obtain water at a lower cost than they would otherwise have to pay.<sup>6</sup>

■ **California.** A temporary federal water bank administered by the Bureau of Reclamation and endowed with federal funds was established in California during the 1976-77 drought to provide for water transfers within the agricultural sector.<sup>7</sup> Then, in 1991, California established an emergency water bank in the fifth year of a prolonged drought, after legislative attempts to promote private transfers produced few transactions. The bank, which reallocated water among willing buyers and sellers, operated in 1991, 1992, and 1994. Initially, the bank purchased water for \$125 per acre-foot (about 10.1 cents per cubic meter) and sold it for \$175 an acre-foot plus delivery charges. In some

cases, the delivery charges exceeded the initial cost of the water.<sup>8</sup>

Purchases by the bank proceeded slowly until the state guaranteed sellers that their price would be adjusted upward to reflect subsequent seasonal price increases. Farmers willing to idle land or shift from diverting surface water to pumping groundwater were the principal sellers. The bank pur-

transfers of water rights, but rules governing where and how the water can be used are restrictive. For instance, out-of-state transfers are prohibited and irrigators receive preference over all other users in purchasing or renting banked water.

■ **Australia.** In Australia, the state of Victoria, which facilitates transfers, defines water rights as explicit

for adapting to the long-term demand and supply shifts that result from population and income growth, urbanization, rising values for instream flows, groundwater depletion, and climate change. Indeed, at some point, as supply and demand conditions change, the historical allocation of water rights becomes inefficient enough to warrant a permanent transfer of rights.

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## As supply and demand conditions change, the

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## historical allocation of water rights becomes

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## inefficient.

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chased 800,000 acre-feet (nearly 1 billion cubic meters) of water, based on early estimates of critical need before the buyers made firm commitments.

California incurred a sizable financial loss when the bank was able to resell only about half of the water. Unsold water was used primarily for carryover storage and for reducing saltwater intrusion into the delta of the Sacramento and San Joaquin Rivers.

In subsequent years, the state required a signed contract with a buyer before committing to purchase water.<sup>9</sup> The third-party impacts associated with these transfers are unknown, but they were probably insignificant compared with the benefits of moving water to higher-value uses during a period of severe drought.

■ **Idaho.** Idaho established the nation's first permanent water-banking program in 1979, and several western states are considering similar actions. Idaho's bank allows temporary or permanent

shares of stored, rather than delivered, water. Under this system of capacity sharing, decisions regarding reservoir releases are made by individual owners of the rights rather than by a central authority. Reservoir operators serve like bankers, making releases on request. The operators also keep track of each owner's balance on a continuous basis by adding inflows and deducting releases and losses from evaporation and seepage. Water users control the timing of their deliveries, and transfers can be made simply by having the operator make the appropriate debit and credit.<sup>10</sup>

Banks can operate at any administrative level, ranging from multi-state to water districts to ditch companies. They can be designed to manage different types of water-use entitlements. And they can facilitate temporary water transfers by developing clear, well-defined rules and procedures that reduce transaction costs.

Temporary water transfers, however, are not particularly effective

## Keeping Deserts Green

**T**ransfers of permanent water rights are permitted, subject to review of third-party considerations, in all the western U.S. states. The process of resolving third-party impacts is often slow, costly, and contentious, however, and the outcome of a proposed transfer can be uncertain. Those orchestrating the proposed transfers face either the challenge of proving that a change will not harm others or the added cost of compensating the third parties who might be adversely affected by the transfer.

Ongoing efforts to meet the water demands of the rapidly growing coastal area of southern California illustrate the challenges of securing additional water in a region where supplies are already fully developed and allocated. The task is made more urgent and difficult because access to some of the region's traditional sources has been blocked.

As a result of environmental concerns, for instance, Los Angeles has been forced to reduce the water it takes from Mono Lake and Owens Valley. The region is also losing rights to the unused entitlements of other states to water from the Colorado River.

The Imperial Irrigation District

(IID), in the southeastern corner of California, owns senior rights to much of California's share of the Colorado River. To help meet the growing demands of the state's southern coastal region, the Metropolitan Water District of Southern California (MWD) agreed in 1989 to invest approximately \$115 million, plus about \$3 million annually for operation and maintenance, to conserve water in the irrigation district through such measures as lining canals to prevent water loss through seepage. In exchange, the MWD acquired the rights to about 100,000 acre-feet of conserved water per year.<sup>11</sup> More recently, San Diego—which depends on, but has a low priority claim to, MWD water supplies—agreed to fund additional conservation investments in the IID in return for conserved water.

These agreements illustrate the opportunities and obstacles associated with using market forces to reallocate water. In these cases, water was transferred from relatively inefficient, low-value agricultural uses to higher-value urban uses; IID's agricultural base was preserved through conservation investments; and the interests of neighboring U.S. irrigation districts were protected.

Yet concluding these apparent win-win arrangements required nearly five years of often contentious negotiations among the participants and interested third parties.

Moreover, agreement in this instance was facilitated because the participants were able to ignore the adverse third-party impacts in Mexico. Indeed, before the canals were lined, some of the water seeping out of them had helped recharge groundwater aquifers used

by Mexican farmers just across the international border. These third-party impacts were ignored because the Mexicans had no recognized legal claim to the water.

Efforts to arrange interstate sales of Colorado River water have been less successful. The 1922 Colorado River Compact among seven western states divided the river equally between the upper basin states

Las Vegas—which already uses most of Nevada's entitlement to the Colorado River—is currently seeking more water. Meanwhile, it lacks rights to surplus flows, and depletion of its groundwater is causing subsidence within the city. Unused upper-basin entitlements to the Colorado River are a logical source of additional supply, and Utah appears to be a willing seller.

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## **Las Vegas lacks rights to surplus flows, and depletion of its groundwater is causing subsidence within the city.**

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(Colorado, New Mexico, Utah, and Wyoming) and the lower basin states (Arizona, California, and Nevada). The upper basin states have never fully used their entitlements. The MWD therefore has been able to take the unused water for free. California, however, is being required to cut back on its use of these surplus flows, and the upper basin states are seeking opportunities to benefit from their full entitlements.

The potential for mutually profitable transfers from the underused upper to the overused lower basin has stimulated several proposed sales. In the 1980s, the Galloway Group, a Colorado corporation with claims to 1.3 million acre-feet of Colorado River water, proposed constructing reservoirs to produce hydropower and store water for leasing to Arizona and southern California. San Diego paid \$10,000 for an option to lease 300,000 to 500,000 acre-feet per year for 40 years, but the project died under a flood of unresolved legal issues.<sup>12</sup>

But consummating this or any other water transfer between the two basins could require renegotiation of the 1922 compact.

Transfers among the lower basin states encounter fewer legal hurdles but, because of their similar hydrology, offer fewer economic benefits than do transfers between the upper and lower basins. In 1997, the U.S. Department of Interior issued a ruling designed to encourage and facilitate voluntary transactions among the three lower-basin states. Arizona has established a Water Banking Authority to purchase its own unused entitlements for storage in groundwater basins and possible sale to California and Nevada. But the opportunities for profitable water transfers among these three states—each of which is trying to meet the demands of rapidly growing metropolitan areas—pale in comparison to the potential benefits of transfers to the lower basin from the upper basin, with its large quantities of unused entitlements.

### Colorado-Big Thompson

The U.S. Bureau of Reclamation's Colorado-Big Thompson project has been cited as a prime example of efficient water marketing. The project involves a series of reservoirs to capture part of the flow of the Colorado River and its tributaries. An average of 230,000

acre-feet of water annually is transferred through a tunnel from the western slopes of the Rocky Mountains to the Northern Colorado Water Conservancy District in northeastern Colorado. Rights to proportional shares of this water are freely traded, unencumbered by third-party concerns, within the district. But limiting sales to within the conservancy district precludes even more-profitable transactions that might take place with buyers outside the Northern Colorado Water Conservancy District. For example, the right to an acre-foot of water in perpetuity has sold for \$3,500 more in the neighboring Denver suburbs than in the conservancy district.<sup>13</sup>

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**A consensus is growing that sustainable economic development depends on treating water as a scarce resource.**

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acre-feet of water annually is transferred through a tunnel from the western slopes of the Rocky Mountains to the Northern Colorado Water Conservancy District in northeastern Colorado. Rights to proportional shares of this water are freely traded, unencumbered by third-party concerns, within the district.

Under western law, downstream users generally own rights to the return flows of upstream users, and transfers must take account of downstream impacts. But since Colorado-Big Thompson water originates in another basin, the district has retained ownership of the return flow of the diverted water. This arrangement does not eliminate third-party impacts, but it does eliminate the need to consider them in transfer decisions.

In this case, the benefits of being able to transfer water readily among agricultural, municipal, and industrial users within the district are likely much greater than the costs of ignoring the third-party impacts.

### Chile Waters

Chile, which has embraced market economy principles for the last quarter century, has introduced measures to encourage water marketing. In 1981, the nation separated water rights from land ownership and made these rights freely transferable. Views differ as to the extent and benefits of the water markets that emerged in response to these changes. One view holds that Chile's water markets function effectively; water moves from lower to higher value uses, prices are responsive to temporary as well as longer-term scarcity, and trading is active.<sup>14</sup>

A less-optimistic view holds that transfers of water rights separate from land ownership are uncommon, involve only a small percentage of users, and result in little actual reallocation of supplies. In particular, several factors are cited as inhibiting sales of water rights separate from land ownership. These include the inflexibility of

the existing canal systems for distributing water, uncertainty as to who actually owns the water rights, a rural culture that believes water should not be bought and sold separately from land, and slow and erratic administrative procedures designed to protect third-parties from injury.<sup>15</sup>

### Sustainable Management

A consensus is growing that sustainable economic development depends on treating water as a scarce resource and using economic principles to guide its management and allocation. Water markets are a means of introducing these principles and allocating supplies in response to changing supply-and-demand conditions. But marketing water differs in important ways from the sales of most goods and services. The fugitive nature of the resource, the variety of services it provides, and interdependence among users limit the potential for efficient water marketing. Additional constraints result from the laws, regulations, and treaties that establish rights to water and limit how it can be used.

Water resources within a basin—precipitation, runoff, water in lakes and streams, and groundwater—are interrelated. Water users become increasingly interdependent as supplies become scarcer. Dams, reservoirs, canals, pumps, and levees make water availability less dependent on the vicissitudes of the hydrologic cycle and more dependent on human decisions. This infrastructure broadens the opportunities for allocating supplies and generates new demands on the resource.

Reservoir operations affect a variety of water uses, such as flood

control, hydropower production, recreation, fish and wildlife habitat, navigation, water quality, and domestic, industrial, and agricultural water supplies. Allocating reservoir capacity for one use affects other users within the hydrologic system. Drawing down a reservoir for flood control, for example, may reduce available supplies when they are most valued for irrigation, hydropower production, navigation, or recreation.

Managing these reservoirs in a way that best serves society is a daunting challenge. In smaller river valleys where water uses are limited, capacity sharing, as practiced in Victoria, Australia, is a way of defining marketable water rights. In a larger, more complex system, the interdependence among users is too great to ignore. Market allocation of water or reservoir capacity in such a system would be inefficient and chaotic.

While markets are not a panacea for achieving efficient and sustainable water use, they can play an important role in achieving these goals under some circumstances. Water markets, whether formal or informal, have a long history of facilitating transfers. Chile and the western United States, two areas where marketing is most advanced, illustrate both the opportunities and limitations of water markets. Water marketing in these countries has largely involved transfers from relatively low-value, inefficient irrigation use to higher-value domestic and industrial uses. Moreover, the sales often provide incentives and funds for water-conserving investments to protect the economic base of the water-exporting community.

Geography and institutional factors, however, have restricted

development of water markets. Moving water outside of its natural channels is costly and subject to economies of scale. Chile's rivers flow from the Andes to the ocean in a series of small, steep-gradient rivers separated by hills. Consequently, it is expensive to move water from one watershed to another or from downstream to upstream areas within the same basin.<sup>16</sup> The frustrated efforts to sell water rights from the upper to the lower Colorado River basins illustrate how institutional factors can limit potentially profitable transfers even where the infrastructure is in place to move water at low cost. The successes and failures in transferring water emphasize that clearly defined, transferable rights are a necessary, but not sufficient, condition for market transactions.

Once transferable rights are established, the most important challenge for creating efficient water markets is developing procedures for expeditiously and fairly handling third-party impacts. Unfortunately, these impacts are not always obvious or quantifiable. Both Chile and the United States allow transfers subject to consideration of these impacts. But the judicial and administrative procedures used to assess these impacts and compensate third parties often impose a high hurdle for prospective buyers.

In spite of the obstacles, the potential gains of transferring water for new uses are encouraging the development of water marketing in many areas. The incentives for voluntary water transfers are strong and will continue to grow as the resource becomes scarcer and the costs of providing water for traditional uses increase.

## A Hot Future

Global warming would likely add to the potential benefits of water transfers. A warming world would alter the hydrologic system and increase the demand for water.

The magnitude, timing, and even direction of climate-induced changes in a region's water supplies are uncertain. The costs of building dams, reservoirs, and canals in anticipation of these uncertain changes are high. But re-examining reservoir operating rules, relaxing constraints on water use, and developing institutions to encourage voluntary exchanges of water through markets would create a system more efficient and able to adapt to whatever the future might bring.<sup>17</sup> ■

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# Water Policy Adrift

*Water planners in the United States, seeking a new paradigm, could learn some lessons from their friends Down Under.*

BY A. DAN TARLOCK

United States water policy is in flux as it moves from the chief paradigm of the 20th century—multiple-purpose development—to one that seeks to use water in more environmentally sustainable ways within the constraints of existing allocations. As a result, the institutions that have managed and allocated this country's water resources are becoming strained and less able to perform their historic function of mediating competing demands for water. Water institutions, including legal institutions, must continue to perform many of their traditional functions and at the same time adapt to new demands such as environmental protection, ecosystem restoration, and social equity.

Throughout the country, the

great era of dam building is over, although the pork mill for navigation-improvement projects grinds on. Indeed, the end of the dam-building era heightens rather than lessens competing demands for water. Today, growing cities compete with proponents of aquatic ecosystem restoration, who compete with traditional users such as agricultural irrigators. All parties compete among themselves for stressed supplies.

In the rapidly growing arid and semi-arid western United States, we have moved from the reclamation era—characterized by large, federally subsidized, regional water projects—to the era of reallocation, conservation, and aquatic ecosystem restoration. The new paradigm seeks to support the traditional consumptive uses such as irrigation, and nonconsumptive

uses such as recreation, fisheries maintenance, and ecosystem restoration, through more efficient use and better management of demand. It also seeks to promote reallocation so that existing unregulated rivers and their ecosystems can be preserved, and degraded ones can be restored. The humid East also faces increased risks of water shortages in some rapidly growing areas, and it must deal with many of the same problems of restoring aquatic ecosystems that the West faces.

## **Stormy Weather**

Shifts in policy have sparked a contentious debate about how the risks of shortages should be shared among competing users. Moreover, disagreements abound over how the benefits of alternative schemes should be distributed. These problems have taken on an added complexity in the debate over global climate change.

The hydrological, economic, and political consequences of global climate change in a given watershed or river basin are uncertain.<sup>1</sup> Some predict that global climate change may alter precipitation and runoff patterns throughout the world. The rub is that both the amount and timing of rainfall may change but the geographic and temporal scale of the change is uncertain. Some regions, such as sub-Saharan Africa, may experience decreased precipitation and more-extended droughts. Others will see increased precipitation and more-frequent and more-severe floods.

Increased precipitation, however, may not translate into more-available water supplies in all regions. In water-short areas with historically variable rainfall pat-

terns, increased precipitation may actually exacerbate efforts to provide reliable water supplies. Warmer average temperatures may cause spring runoffs to come earlier and evaporate faster, snowpacks may melt earlier, and more precipitation may fall as winter rain rather than snow.

Increased, but out-of-cycle, rainfall is the projected pattern for parts of the western United States. Wetter, warmer weather could strain existing storage systems that currently provide reliable regional water supplies.<sup>2</sup> Existing reservoirs may not be able to capture the increased winter runoff, causing serious shortages in the summer.<sup>3</sup> In addition, states and regions may have to adapt to a series of ecosystem changes due to plant and animal population shifts caused by changing climatic patterns. All these new uncertainties must be factored into any adaptation strategy.

### **Policy Adrift**

New demand and greater uncertainty about available supplies mean today's water users and managers face difficult choices. These difficulties are exacerbated by increasingly thin institutional buffers between groups with diametrically opposed points of view. No single group, such as irrigated agriculture or municipal water supply, controls the agenda and the water resource agencies. The diffusion of power among old and new stakeholders means that agencies have increasingly less power to resolve conflicts by imposing a solution.

In addition, the two major institutional frameworks—state water law and federal water resources development—are under great

stress. State water law has traditionally determined the allocation of water among competing residential, industrial, and agricultural users and hydroelectric power generators. But increasingly the market, rather than state water administrators, controls the allocation of water.

While the federal role remains important, it is changing and diminishing. John Volkman, a longtime student of the Columbia River—which has been primarily dedicated to hydroelectric power generation, navigation, and irrigation to the detriment of ecosystem services—has characterized the conflicts among interests in that basin as a contest between a working river and a river that works. Change is difficult on developed rivers because most users, especially established consumptive and nonconsumptive ones, view the allocation of water among competing users as a zero sum game.

In the past, when water policy meant developing national water resources, the federal government was able to solve most conflicts by simply providing more usable water by funding a large project. But modern water policy is no longer an important national political issue, and the federal government is now more of a regulator than a supplier. The new water era is therefore much more diffuse and decentralized.

At the federal level, the two major historic water agencies—the Bureau of Reclamation and the U.S. Army Corps of Engineers—face shrinking budgets. They must also share their authority with such agencies as the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the U.S. Environmental Protection Agency, which

are not water managers per se but do have considerable authority to influence specific management decisions—especially decisions that could alter habitats and aquatic ecosystems—and are becoming major players in water policy.

While the Corps and the Bureau of Reclamation still have a political constituency, they lack much of the autocratic power that they once had. Much of the old planning infrastructure has been dismantled, and the Corps and the Bureau are caught between their old constituencies and efforts to expand their mission to include environmental management and conservation. The Bureau of Reclamation's draft strategic plan for 2000 through 2005, for instance, grandly proclaims that the Bureau's mission includes "managing, developing and protecting water and related resources to meet the needs of current and future generations."

### **Hands Off**

The institutional context of the new era differs markedly from past regimes. For a variety of reasons, it lacks the clear, coherent vision and focus on multiple use.

First, the new policy is still largely a negative reaction to the social and environmental costs of multiple-purpose development—especially large dams—and it will take time for a clear vision to evolve. Powerful new ideas are emerging, such as the goal of the "normative river," which seeks to restore dammed and channeled rivers to a state closer to the original. These ideas are complemented by new management theories that consider ecological processes as continually evolving rather than reaching a permanent, natural equilibrium. These new approaches have great

relevance for water management. But ecologists rather than engineers are the intellectual force behind the new vision, and their influence is still marginal.

Second, in contrast to multiple-purpose development, the new policy lacks legislative and executive guidance. Initiatives are more likely to come from the bottom up—from local agencies and non-governmental organizations—than from the top down, and the effectiveness of these initiatives is very much in doubt.<sup>4</sup>

Modern water policy is a victim of post-Reagan minimalist government, which seeks to reduce the federal role in setting policy and increase the role of the states and local agencies. Today, there are no George Norrises, Robert Kerrs, Clinton Andersons, or Henry Jacksons—strong legislators who helped frame landmark natural resource-development projects and environmental policies, such as the Tennessee Valley Authority, the Arkansas River Navigation Project, and the National Environmental Policy Act—to articulate and implement visionary national and regional programs.

Instead of providing leadership, Congress is more likely to intervene in specific disputes to benefit a narrow but powerful local constituency, as it did when it recently forbade the Corps of Engineers from changing the Missouri River Master Manual, the federal guidelines that govern the river's management. One proposed change would have regulated the river's flow to improve habitat for endangered species such as the pallid sturgeon. The navigation industry and farmers, however, opposed any revision of the manual as it threatened to hurt them eco-

nomically. President Clinton vetoed this meddling, and Congress was unable to override the veto. While this was a minor victory for river restoration, the process also illustrates how minimalist government will often lead to policy gridlock.

Third, the traditional mandate to allow for multiple uses of water resources had a firm legal foundation, unlike the new vision. The new paradigm—which attempts to balance environmental and economic interests—is contested by many traditional water users, and thus efforts to reform water policy can be blocked by powerful legislators beholden to them.

#### **End of an Era**

The current minimalist federal water policy is apparent in two recent federal water-commission studies. Federal water commissions have historically played an important role in setting the national water agenda. In 1968, Congress created a National Water Commission to provide guidance for the expected continued large-scale regional water projects such as transbasin diversions, which were becoming increasingly controversial for both economic and environmental reasons. The commission's bold report examined all aspects of water policy, focusing on the use of markets to test the efficiency of alternative allocations. It also legitimized incorporating environmental values in water allocation and inadvertently provided a blueprint for the end of the reclamation era.

In 1992, in a similar attempt to review the complex mix of local, state, and federal water policy that no longer provided a clear vision of how to manage western water resources, Congress autho-

rized the Western Water Policy Review Advisory Commission, appointed by President George Bush. This commission turned out to be a political orphan, however, after its sponsor, Senator Mark Hatfield of Oregon, retired from the Senate. The new Clinton administration tried to kill the commission, but Congress intervened to save it.

The strange mix of members on the commission—including private citizens, cabinet secretaries, and members of Congress—ensured that it was gridlocked from the start. Congressional republicans, for example, immediately took off the table the two most important issues: reorganization of congressional jurisdiction over water resources and the idea of executive integration of water resources activities. A final report—*Water in the West: Challenge for the Next Century*—was published after a majority of the commission reached a compromise with two members, each with a single idea. One wanted a watershed governance structure that would give states and local users more freedom to decide how to comply with federal environmental mandates, and the other wanted increased coordination of agency water resources budgets. The resulting report is like Richard Strauss' opera *Ariadne auf Naxos*, which overlays an Italian buffo opera over a Greek tragedy.

The report endorses a controversial experimental watershed-management program that has the potential to displace federal standards with local ones. It also contains a full discussion of the transition from reclamation to reallocation, justifies a need for a new vision of river systems and water-

sheds, and examines the institutional implications of the end of the reclamation era. The report, however, seems to have suffered the fate of many similar reports and modern operas; they receive initial praise and interest and then disappear into the archives.

As students of international relations would predict, the federal government's diminished role has set off intense competition among water claimants for supplies to meet the demands of urban growth and environmental restoration. In general, state governments have not taken up the slack and assumed the federal government's traditional mediating role. These developments place new stresses on water management and allocation law.

Environmental laws grant federal agencies considerable leverage to influence decisions about water allocation, but the regulatory agencies can neither make the necessary allocation decisions nor project operation changes. In addition, the regulatory power is often so drastic that the political costs of full enforcement are too high. Thus, the federal government increasingly functions more as a facilitator of regional stakeholder settlements than as a regional development bank or traditional regulator, although the threat of federal regulation is always in the background.<sup>5</sup>

### **Conflict of Interest**

Water law has two basic, related functions: to create correlative private property rights in scarce resources and to impose limitations on private use, in the public interest. There is inevitable tension between these two functions. Correlative property rights recognize

the rights of individuals to use a portion of a common supply while simultaneously protecting the interests of other users. Limitations on private use promote broader public values.

In general, states set the basic allocation rules, except for federal interests such as Indian Tribes and public lands. States also have the discretion to define the public interest, although they have not historically exercised this discretion to significantly limit private water use.

State law continues to perform these functions, but it has remained relatively static. There are both virtues and vices in this stasis. The states have not been interested in taking up the slack of the ever-shrinking federal government. They primarily continue to administer the laws of allocation. On one level, this facilitates changes through water markets, which have emerged as a major reallocation policy instrument. Water rights have always been inalienable, but the prevailing assumption was that water would be used on the land where the right was initially applied. This assumption held more or less true when the principal form of conservation was supply augmentation, but this is no longer the case. Growing cities, power generators, and environmental interests are increasingly relying on the purchase of existing irrigation rights to meet the demand for new supplies.

The legal system's emphasis is shifting from setting the ground rules for the acquisition of rights and their enjoyment to lowering the transaction costs of transfers. Aside from specific commitments to environmental protection and restoration, there are few limits on the transport of water from water-

sheds to cities outside the watersheds or on the power of cities to decide how much they need. But this limited role prevents the states from exercising control over the pace of reallocation or adjusting to new demands. For example, the insistence by many westerners that land and water are exclusive individual property rights with no community dimension undermines new community efforts to control their destiny. Land and water are alienable property rights, and individual rights holders are generally free to respond to market pressures without regard to the impact of their decision to break up a parcel of land or transfer a water right to the surrounding community.

### **Goldrush Era**

A recent decision by the California Supreme Court shows the danger of refusing to temper the protection of vested rights with accommodation of new demands.<sup>6</sup> In 1996, a trial judge imposed a negotiated settlement on all groundwater users in the Mojave River Watershed. The decision did not strictly follow California groundwater law, but the state supreme court had a long tradition of approving allocation regimes that balanced groundwater conservation with equal access among all users. The court's decision that courts must determine the prior rights of all pumpers is, of course, a classic example of the rule of law, but it also illustrates the difficulties of adjusting, rather than eliminating, historic entitlements to respond to current conditions.

In an editorial, the *Sacramento Bee* characterized the opinion, somewhat inaccurately, as a "Gold Rush Era" decision, but the result

shows that holdouts—those who refused to accept the negotiated settlement—can use law to raise the costs of systemwide allocation adjustments that balance resource conservation and use.

The California decision is not an anomaly. In general, states have the poorest track record of incorporating environmental protection values into existing and future water-allocation regimes. There are some exceptions, of course. The Hawaii Supreme Court, for example, recently integrated the public trust doctrine, which provides that “public natural resources are held in trust for the benefit of the people,” into its statutory water-allocation regime to impose potentially strict in-stream flow-protection duties on the state. Initially, the law of water rights has little weight to leave water in a stream, but more and more states are trying to maintain minimum stream flows to protect fisheries and other environmental values. In a dispute over the allocation of a ditch that carried water from the windward to the leeward side of Oahu, the Commission on Water Resource Management set interim in-stream flows for windward streams and denied several water-use permit applications. The court held that the commission correctly interpreted the public trust doctrine to give priority to the protection of fresh groundwater and surface-water resources because “the people...have elevated the public trust doctrine to the level of a constitutional mandate.”<sup>7</sup>

### **Changing Tack**

One possible side effect of the resistance of law to change is that courts may block reallocation schemes because they conflict with

vested entitlements. This possibility has encouraged ad hoc solutions to conflicts, thus discouraging stakeholders from claiming their full entitlements. Around the country, all levels of government are trying a number of important ad hoc basin-restoration experiments to solve specific basin problems.

These efforts generally begin as an attempt to deal with a perceived crisis for threatened or endangered species. Once sufficient bipartisan political support has been mustered, however, they have evolved into a broader effort to accommodate both historic and new basin uses. The federal government remains an important participant, but power is shared much more broadly with states and stakeholders than in the past.

The real question is whether these settlements will favor process over substance and in the end fail to reach long-term consensual solutions about how the real costs of reallocation will be shared.

The California-Bay Delta restoration process, for example, has been underway for almost a decade, but the parties have developed neither a clear focus—the restoration of the deteriorating Bay Delta ecosystem—nor a plan to accommodate ecosystem restoration with continued consumption for agriculture and municipal and industrial use. Many promising ideas such as adaptive ecosystem management—which sets ecosystem indicator targets and takes the necessary actions to meet them—have emerged, but the jury is out on their long-term success. The recent election and Supreme Court selection of a new president injects great uncertainty into the process and may encourage many stakeholders, such

as irrigated agriculture, to dig in their heels and refuse to make necessary concessions.

### **Simulating Nature**

The recent federal legislation to fund restoration of the Everglades is an example of an effort to apply new management techniques to save a degraded ecosystem. The current thinking is that the system must be restored through intense management of the existing built system of canals and drains that caused its degradation. This is not a simple return to the status quo prior to development. Rather, it involves the artificial reconstruction of the environment before human intervention, using sophisticated techniques such as computer models of water flow and experimental management strategies that mimic the natural ecosystem.<sup>8</sup>

Agricultural use of fertilizers containing phosphorus have contributed to unhealthy algal blooms in the Everglades. Experts widely agree that more low-phosphorus water must be put back in the system. In addition, diversion of water for agricultural irrigation has disrupted the natural cycle of water flow from north to south. Sheet flows must be more continual for longer periods of time during the wet season to sustain the glades during dry periods.<sup>9</sup>

Experimental releases of water into the glades have taken place, but the results are still uncertain as the experiments are conducted in the absence of scientific certainty about species and system responses to restoration efforts and management strategies. These efforts, therefore, must be constantly evaluated and often revised.

In February 1999, for example, a group of biodiversity experts complained to the secretary of the Interior that the federal government's actions had a high risk of failure because water releases into the park were insufficient to maintain the Everglades.<sup>10</sup> Secretary Babbitt immediately agreed to the creation of a new scientific panel to monitor the experiment.<sup>11</sup> In October 2000, the Senate approved a \$1.4 billion-dollar restoration plan as part of a larger federal-state cost-sharing and cooperative strategy.<sup>12</sup>

The Florida example may not be a good model for other restoration projects, however, because the Everglades are a heritage resource whose restoration has been widely accepted. In addition, federal and state governments are dealing with the major stakeholders—such as water-management districts, irrigators, and environmentalists—who will be adversely affected as more water is sent into the park and phosphorus loads must be reduced—in the old fashioned way: throwing money at them.

### **Doing It Right**

While American water managers grapple with an uncertain tangle of legal precedent and environmental manipulation, Australia is conducting an important experiment in flow maintenance and ecosystem restoration management on its largest river system, the Murray-Darling.<sup>13</sup>

The population of the Murray-Darling basin is relatively small, since Australia's population is concentrated along its coast. Still the basin contains 42 percent of Australia's agriculture—which consumes about 78 percent of the country's water supply—most of

the country's major inland cities, and its capital, Canberra.

Like the United States, Australia is a federal system, and the Murray-Darling is an interstate river system. The Murray originates in the Snowy Mountains of New South Wales and Victoria, while the Darling originates in southern Queensland and joins the Murray near Mildura, Victoria.

The system has been severely degraded—especially from increased salinity—due to diversions and dams. In 1992, the federal government and the basin states agreed on the Murray-Darling Initiative to conserve the river's ecosystem. The initiative led to the adoption of the federal-state Murray-Basin Agreement and the creation of a joint federal-state commission overseen by a federal-state ministerial council.<sup>14</sup>

Unlike a United States interstate compact or an international treaty, the agreement imposes much more detailed land-use and water-management duties on the parties and is constantly being amended by new agreements. It has bite because it allocates the flow among the basin states,<sup>15</sup> and it vests a commission with the power to control releases from specified upstream storage facilities. The Murray-Darling Commission now runs the river—overseen by a ministerial council, composed of ministers from the participating territory and states—and a stakeholder advisory board composed of state representatives, farmers and other rural interests, environmentalists, and aboriginal representatives.

This experiment is the best available model for incorporating a river into a transboundary water resource managed to meet the needs of its many users. The effort

has the three key elements that many of the current ad hoc United States experiments lack: a formal cooperative institutional structure, a relatively clear management objective, and a plan to limit inconsistent consumptive uses.

The most important precedent with potential international implications is the commission's adoption of a base-flow regime. This establishes the average quantity of water flow necessary to sustain a healthy ecosystem, and it mandates that any management regime should maintain that base flow. The commission's goal is to set base flows for ecosystem restoration, based on information about how flows affect the riverine environment. This regime is imposed by the law of the four basin states—Queensland, New South Wales, Victoria, and South Australia—on existing entitlement holders throughout the basin.

### **Cap and Trade**

The problem with establishing new regimes on developed river basins is that users have acquired, or at least claim to have acquired, vested rights. Yet federal and state governments recognize the need to limit water withdrawals, establish base flows, and stabilize and restore productive agricultural areas, especially those degraded by salinization. To that end, in 1996, the commission announced caps on water use.

The caps—which are the “cornerstone of a number of policies designed to manage water resources for scarcity: water trading, environmental flows and the security of property rights”—impose yearly limits on diversions of water in the four basin states and the Australian Capital Territory.<sup>16</sup> Each

state or territory's cap will vary from year to year according to the supply of water. The caps are administered by each state and will require aggressive management, since agricultural water diversions are increasing in both New South Wales and Queensland. In 1996 and 1997, three major subbasins in New South Wales exceeded the caps.<sup>17</sup> Staying within the limits of the caps will require innovative management strategies, such as augmenting the surface-water supply with withdrawals of groundwater, abandoning the "use it or lose it" administration of water licenses, and implementing an accounting system to balance water use over a period of time.

Rollbacks in existing uses can be fair and efficient and at the same time promote environmental objectives. In major river systems, agricultural water use is almost always wasteful. Agriculture also uses more water than it is legally entitled to, so river managers have some flexibility to experiment with more-efficient use of agricultural water without unduly disrupting the expectations of legitimate users.

The most significant device Australia has used to ensure flexibility is the Pilot Interstate Trading Project in the Mallee Region of South Australia, Victoria, and New South Wales along the lower Murray River. Water prices and agricultural crops are comparable among the three states.

Under the pilot program, individual diverters with high-security water rights such as irrigation licenses may sell water across state lines, provided that the water licensing authorities in each state agree to the transfer.<sup>18</sup>

One of the major unresolved is-

ssues in water marketing is how to integrate the benefits of markets with environmental protection objectives. The Murray-Darling Pilot Program does this by establishing exchange values—the amount of water that can actually be transferred—among states. Trades by upstream diverters from New South Wales to Victoria and from Victoria to South Australia have a 1.0 exchange rate, which means that 100 percent of the entitlement can be transferred downstream. But transfers from South Australia to the upstream states of Victoria and New South Wales have an exchange rate of 0.9 so that only 90 percent of the entitlement can be transferred.<sup>19</sup> Thus, the capacity of the lower river to continue to dilute the salinity will be protected. To integrate the program with the basin initiative, all transfers must meet a no-net-detriment-to-the-environment standard and must be consistent with environmental flows set for the Murray.

### **Breaking the Gridlock**

The current state of disarray in U.S. water-use policy leaves many critical interstate water basins dangling under Solomon's sword. While the Murray-Darling Initiative is still a work in progress, it could serve as a model for a new regime in water management in the United States. Either through presidential leadership or congressional initiative, policymakers need to forge a clear vision for the future, based on a common understanding that long-term environmental goals are also consistent with sustainable economic development. Otherwise, competing interests will drain the life from America's rivers. ■

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### **NOTES**

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8. For a brief discussion of the recreation of simulated naturalness as a new management baseline, see *River Resource Management in the Grand Canyon*, National Research Council (Washington, DC: National Academy Press, 1995), pp. 38-49.

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12. Council on Environmental Quality, "The Florida Everglades" <<http://www.whitehouse.gov/CEQ/990630b.html>>.

13. See Murray-Darling Basin Commission, *Annual Report* (1998-1999) <<http://www.mdbc.gov.au>>.

14. *Ibid.*

15. *Ibid.*, Part X.

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17. Murray-Darling Basin Commission, *Water Audit Monitoring Report 1996/97, Report of the Murray-Darling Commission on the Final Year of the Interim Cap in the Murray-Darling Basin* (October 1998) <[http://www.mdbc.gov.au/naturalresources/policies\\_strategies/projectscreens](http://www.mdbc.gov.au/naturalresources/policies_strategies/projectscreens)>.

18. The procedure is outlined in Murray-Darling Basin Commission, *The Pilot Interstate Water Trading Project* <[http://www.mdbc.gov.au/naturalresources/policies\\_strategies/project\\_screens/pilot\\_watertrade.htm](http://www.mdbc.gov.au/naturalresources/policies_strategies/project_screens/pilot_watertrade.htm)>.

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# Trading on Water

*Trading can be a cheaper answer to water quality problems, creating a win-win solution for all.*

**BY SUZIE GREENHALGH AND PAUL FAETH**

Over the centuries, water has provided society with numerous products and services, including transport, food, drinking water, irrigation, recreation, and protection. The world's lakes, rivers, and oceans have also been used as a dumping ground for by-products of industrial development and residential refuge. Until recently, however, very little attention was paid to water quality.

This ignorance of human influence on water quality culminated in such notorious events as Ohio's Cuyahoga River catching on fire in 1969 and the lawsuit against W.R. Grace over contamination of drinking-water wells in Woburn, Massachusetts, which was memorialized in the book and movie *A*

*Civil Action*.<sup>1</sup> The Cuyahoga fire, in fact, helped spark the rise of environmental movements, the establishment of the U.S. Environmental Protection Agency, and the passage of the federal Clean Water Act in 1972.

## **Water Woes**

Water quality is a relative term. The quality of water needed for drinking, recreation, fishing, and aquatic habitat is higher than that required for transportation or agriculture. In 1998, 45 percent of assessed U.S. rivers and streams and 54 percent of assessed lakes, reservoirs, and ponds were threatened or impaired for their designated uses.

The U.S. coastlines are similarly affected. Ninety-eight percent of the Great Lakes shorelines and 24

percent of the ocean shorelines assessed were listed as threatened or impaired. The causes of impairment include nutrients, siltation, pathogens, metals, toxics, pesticides, organic matter, temperature, and oxygen-depleting substances.<sup>2</sup>

The problem is not restricted to just the United States. Across the world, more than a billion people do not have access to safe drinking water. In developing countries, water quality problems principally result from untreated sewage and industrial wastes, while developed countries are plagued more by agricultural runoff and industrial effluents.<sup>3</sup>

Evidence of water quality impairment is abundant. In 1991, the 600-mile (1,000-kilometer) algal bloom on the Darling River in Australia was the result of modifications and reductions in water flow, pollution from sewage treatment works and industry, agricultural runoff, and lower than expected rainfall.<sup>4</sup>

Just as dramatic was the cyanide spill from the Aurul Gold Mine into the Lapus and Somes Rivers at Baia Mare in northern Romania in 2000. This spill made its way to the Tisza River in Hungary, creating a carpet of dead fish before reaching the Danube River in Yugoslavia.<sup>5</sup>

More subtly, the decline of the blue crab and oyster fisheries in the Chesapeake Bay in the United States, caused by deteriorating water quality and over-harvesting, stimulated the states and districts draining into the bay to form an agreement in 1983 to restore the bay's biota.

Restoration programs consist of nutrient reduction from agricultural lands and wastewater facili-

ties, toxic chemical reduction from industry and other sources, fisheries management, and habitat restoration.<sup>6</sup>

### **Cause and Effects**

Some water quality problems are local while others have far-reaching consequences. Consider nutrient pollution, for example. Agricultural fertilizer typically contains two nutrients: phosphorus and nitrogen. Phosphorus, which reaches water bodies attached to soil particles, causes algal blooms and eutrophication in freshwater ecosystems. It is typically a local problem.

Conversely, nitrogen is highly soluble, entering water bodies through runoff, leaching, and atmospheric deposition, and its effect is generally felt some distance from the actual source of the pollution.

The Gulf of Mexico's hypoxic—oxygen-depleted—zone, coined the “Dead Zone,” has been attributed to nitrogen from farmland in the Mississippi basin, principally the Missouri River.<sup>7</sup> This oxygen-starved area in the Gulf grew to an all time high of 8,000 square miles (20,000 square kilometers) in 1999.

The increasingly pervasive red tides in the East China Sea are yet another example of nitrogen-induced water quality problems. Nitrogen applied by farmers along the Yangtze River is necessary to meet the increased food demand of a growing Chinese population, but it is also causing substantial economic damage to the region's seafood industry.

In 1998, more than 100 fish farmers in a Hong Kong fishing village used the motors of their sampans to turn back the red tide

threatening their fish farms. This action saved about two-thirds of their fish.<sup>8</sup>

Water pollutants fall into two broad categories: point-source and nonpoint-source pollution. Point-source pollution occurs wherever the pollutant can be pinpointed to a specific source of origin, such as the discharge from a pipe into a water body. Nonpoint-source pollution, on the other hand, is diffuse in nature and its precise origin cannot be identified. Examples of this type of pollution include contaminated runoff from farmland, construction sites, and urban areas.

Improvements in monitoring technology and the enforcement of pollution regulations have led to significant reductions in point-source pollution in the developed world.

In the United States, municipal wastewater treatment plants and industrial facilities all require permits under the Clean Water Act to discharge into rivers, lakes, and oceans. These permits limit the amount and type of pollutants discharged. Violations of these permit levels result in fines. In 1999, more than \$20 million in criminal penalties were assessed under the act.<sup>9</sup>

In the developing world, the situation is more desperate. Buenos Aires, Argentina, for example, treats only 2 percent of its wastewater. The costs of collection and primary treatment are still expensive—about \$1,500 per household—in many developing countries, with the costs of meeting the more stringent regulations of developed countries being even higher.<sup>10</sup> Even though the technology is available to treat municipal wastewater, significant institutional changes in planning,

finance, operations, and management of treatments plants are needed before even point-source pollution can be effectively reduced in these countries.

Nonpoint-source pollution is more difficult to identify, monitor, and control, and it is only now that the developed countries have started to expend significant time and money on addressing this problem. So, it may be some time before this source of water quality pollution is confronted in the developing countries.

### **Regulation**

A number of mechanisms are being used to address water quality problems around the world. As the extent and nature of water quality impairment has become more prevalent, the set of potential solutions has also grown.

The earliest efforts at controlling water quality took a regulatory command-and-control approach. This was either in the form of technology-based or performance-based standards placed on municipal wastewater treatment plants and industrial facilities. Technology standards specified the type of equipment or processes that each industry needed to adopt to meet a water quality target. A performance standard, on the other hand, specified the target and gave industries and treatment plants greater flexibility in the methods they could employ to meet that target.

Even though this regulatory approach achieved initial success, it does place heavy financial burdens on facilities to continually upgrade their equipment, and regulators must keep abreast of new technological advances. It provides little opportunity or incentive for facilities to be innovative.

In the United States, between 1974 and 1994, local governments and the federal construction grants program spent approximately \$213 billion for the construction or upgrades of municipal wastewater treatment plants to control point-source pollution. During the next 20 years, an additional \$330 billion will likely be required to construct new plants and replace aging facilities to meet the water quality level and treatment demand of a growing population.<sup>11</sup>

One significant omission from this regulatory requirement in the United States is the absence of control over concentrated animal feeding operations. To require a permit, a farm must be larger than 1,000 animal units—one unit being equivalent to a cow and calf or 1,000 pounds (450 kilograms) of liveweight—and the government must deem that the farm is discharging into a water body causing a water quality problem. As a result, only 1 percent of the 1.1 million farms in the United States have permits under the Clean Water Act.<sup>12</sup>

Given that livestock waste is about 130 times greater than human waste, there is remarkably little control of this source of water quality degradation. The 1,600 dairy farms in California's Central Valley, for instance, produce an amount of waste equivalent to that of 21 million people, or seven times more than the people living in the Central Valley produce.<sup>13</sup> Thus, the existing permitted discharge facilities have to shoulder the burden of increasingly stringent water quality standards, while other significant sources of pollution remain uncontrolled.

Nonpoint-source pollution,

whose source is more difficult to identify than point-source discharges, cannot be as easily controlled by regulation. Moreover, the cheaper, easier-to-achieve reductions in pollution have already occurred, and costs are escalating for point sources to meet the tougher water quality standards imposed on them. These factors have led to an evolution of various economic policies aimed at improved water quality.

### **Subsidies and Taxes**

Taxes and subsidies have been used to indirectly reduce pollution. Taxes place a penalty on polluters, much like the stick in the carrot-and-stick analogy. Conversely, subsidies are the carrot and provide incentives, usually financial, for polluters to reduce their emissions.

The United States has used a number of subsidy-based policies to influence water quality. The Conservation Reserve Program, for instance, was aimed at reducing soil loss from agricultural land. Almost 34 million acres of highly erodible cropping land had been taken out of production by 1990, with the 2000 enrollment at 31.5 million acres. In return for retiring their land for 10 years, farmers receive a yearly rental payment from the government, with the level of payment reflecting the productivity of the land. The estimated net social value of the program between 1985 and 1990 is \$4.2 billion to \$9 billion, with \$1.3 billion to \$4.2 billion in benefits being attributed to improved surface water quality.<sup>14</sup> By comparison, the net government cost of the program over this period was estimated at \$6.6 billion to \$9.3 billion.<sup>15</sup>

A similar program, the Wetland

Reserve Program, was introduced in 1990, providing financial incentives for farmers to voluntarily restore and protect wetlands. Wetlands are recognized as important filters for many substances that degrade water quality; they also provide flood control, wildlife habitat, and recreation. As of July 2000, more than 900,000 acres of wetlands were enrolled in this program.<sup>16</sup>

Encouraging establishment of buffer strips and other conservation practices is also achieved through cost-share arrangements within programs like the U.S. Department of Agriculture's Environmental Quality Incentive Program, which provides financial and technical assistance to help farmers protect soil, water, and other natural resources.

Where emissions can be tied to inputs such as fertilizers and pesticides in the production process, taxing these inputs has been a common practice in OECD countries. Fertilizer taxes have been introduced in Finland, Norway, and Sweden. Frequently, the revenue from these taxes is earmarked for certain uses. Sweden, for instance, uses its fertilizer and pesticide tax to finance environmental research and improvements.

Earmarking these funds for such projects improves the political acceptability and transparency of the taxes, but a number of pitfalls can trip up the unwary. Inducing polluters to reduce their discharges is only partially achieved with earmarking, and sometimes it can provide incentives to over-invest. In certain river basins in the Netherlands, for instance, high-water effluent charges resulted in 20 percent over-capacity in treatment facilities.<sup>17</sup>

## Trading

Perhaps the most exciting and innovative mechanism being discussed today is water quality trading. Trading is generally talked about in the context of nutrient impairment but has been used with other substances like biological oxygen demand.

As an adjunct to regulation, trading increases the flexibility facilities have to meet a water quality standard, thereby lowering the overall cost of compliance. Each industrial facility or municipal wastewater treatment plant faces different regulatory compliance costs, depending upon size, scale, age, and overall efficiency. The cost in meeting tighter water quality standards is therefore cheaper for one facility than for another. Those facilities whose upgrade costs are lower thus have an opportunity to make additional reductions beyond their obligation and to sell these additional reductions to facilities whose costs are higher.

Two types of trading are currently in vogue: open and closed. Closed trading is the most common type. It operates under a cap-and-trade system in which an upper limit on the total emission of a particular pollutant from all dischargers in a specified area, such as a watershed, is mandated by law, and facilities are allowed to trade discharge levels as long as the collective discharge from all sources is below the cap. The TMDL—total maximum daily load—process under the Clean Water Act is an example of a regulatory cap being placed on water quality within watersheds or impaired areas. Dischargers are allocated an emission allowance and any emission reduction that the discharger achieves below the regu-

latory standard, commonly called credits, can be traded.

Open trading is used where the ambient water quality conditions are being met and there has not yet been a regulatory cap implemented for a watershed. This type of trading allows for economic growth and development to occur while maintaining or even improving water quality, and it can be used to avoid or delay the imposition of regulation. For trading to occur, a baseline for emissions in the watershed is determined.

The definition of the baseline can vary depending on the institutions that are establishing the market. Under the trading rules being established for the water quality market in Michigan, for example, the baseline refers to the current land or nutrient management practices being implemented by land or industry owners in each watershed.<sup>18</sup>

Credits are generated when reductions below the baseline are made. These credits can either be banked, traded, or used to comply with the permitted discharge limits for individual point sources. This system offers operational flexibility and water quality improvements in the absence of mandatory caps. As with closed trading, the reductions must be real, surplus, and enforceable before they can be counted as credits.

Trading can occur between two point-source facilities, like municipal wastewater treatment plants, or between a point source and nonpoint source such as a farm.

Point-source facilities are generally controlled by a discharge permit; nonpoint sources are not.

The inclusion of nonpoint sources into trading programs has

raised the question of uncertainty in the amount of reduction actually achieved by these sources. For nonpoint sources to reduce their nutrient contribution to water bodies, some kind of best management practice is typically implemented. These practices may include changing tillage practices, excluding livestock from water bodies, or creating filter strips of vegetation along a water body to provide a buffer.

To address this reduction uncertainty, a trading ratio or discount factor is commonly applied to nonpoint-source reductions. For example, if the trading ratio is set at 2 to 1, a nonpoint source has to produce two pounds of nutrient reduction to create one pound of credit.

## Case Studies

Many studies have illustrated that the inclusion of trading as part of a water quality improvement strategy achieves significant improvements at a much lower cost than is achieved by other mechanisms. In a recent study of nutrient reduction options in three watersheds in the Upper Midwest, for instance, trading was by far the most cost-effective option.<sup>19</sup> The study compared the costs of meeting tighter nutrient standards by requiring point sources to meet 100 percent of the obligation, by implementing best management practices through agricultural conservation subsidies, by a combination of point-source performance requirements and point-source/nonpoint-source trading, and by a joint trading and targeted performance-based conservation subsidy program.

For the Saginaw Bay, Michigan, watershed, the joint trading/targeted

conservation subsidy scenario reduced the costs of meeting tighter water quality standards by 82 percent compared with traditional command-and-control regulation on point sources.

Similar, but smaller, cost reductions were seen for the Minnesota River watershed in Minnesota and the Rock River watershed in Wisconsin.

Water quality trading programs have been in existence since the 1980s but have not enjoyed the successes of some other trading programs like the Acid Rain Trading Program.

The first trading program for water quality in the United States was established for the Dillon Reservoir, a source of drinking water for Denver, Colorado, 70 miles to the east. Rapid urban growth, decreasing water quality, and increasing reliance on the reservoir for Denver's drinking water led to the creation of the Dillon Bubble, the watershed area that feeds into the reservoir.

Under the trading program, point sources within the bubble could purchase phosphorus reduction credits from existing urban nonpoint sources like lawn and road runoff and septic tank seepage. In practice, however the upgrading of the municipal wastewater facilities achieved such high phosphorus reductions that no trades were made between point and nonpoint sources. The only trades to occur were two nonpoint-source trades.

The Cherry Creek Reservoir, also a source of drinking water for Denver, has a similar program. As the areas around these reservoirs further develop, more trades are expected to occur within these programs.<sup>20</sup>

The Tar-Pamlico program in

North Carolina is probably the best known water quality trading program in the United States. This program was established to avoid tighter point-source permit limits and to reduce the cost of meeting nutrient load reduction requirements. When the North Carolina Division of Environmental Management designated the Tar-Pamlico basin as nutrient-sensitive waters, in response to increasing numbers of fish kills and algal blooms, a coalition of municipal and industrial dischargers formed the Tar-Pamlico Association.

The association agreed to reduce its nutrient discharges into the basin and to share a single nitrogen discharge limit in lieu of individual nitrogen limits being assigned to each discharger. The association enforces the limit and internally allocates discharge limits among its members. If the association exceeds the annual limit, it pays into an agricultural fund that farmers draw from to pay for best management practices, which reduce the amount of nonpoint-source nutrients they discharge into the basin.<sup>21</sup>

The Tar-Pamlico program can be considered a hybrid between a trading program and an effluent tax. The credits are purchased for a fixed price, and there is no direct connection between the credits point-source dischargers use to meet nutrient limits and the credits generated through the best management practices fund.<sup>22</sup>

In Australia, a salinity trading scheme along the Hunter River uses real-time trading of salinity credits to ensure that salinity levels in the river do not exceed a regulatory limit. Salinity levels, which have increased from coal mining activities, electricity gen-

eration, and land clearing, were starting to harm irrigated agriculture in the region. The solution was to develop a trading scheme that allocated salt credits to participants.

During times of high river flows, participants are able to discharge salty water according to the number of salt credits they hold. Credit holders can use their credits for their own discharges or they can trade credits to other dischargers. This scheme provides a cost-effective mechanism for reducing salinity levels in the Hunter River, as well as a mechanism that allows new mines or industries to enter the region without compromising water quality.<sup>23</sup>

### **Trading's Potential**

As the extent and cause of water quality problems are clarified, the potential for trading as an integral part of the solution is steadily growing.

Now that nitrogen from the Mississippi basin has been identified as the main culprit in causing the Dead Zone in the Gulf of Mexico, who is to say that trading could not play a key role in alleviating the problem?

To date, most trading programs have concentrated on phosphorus, which affects freshwater ecosystems and necessarily raises concerns over local water quality problems, usually at the small watershed level.

These ecosystems are not greatly harmed by nitrogen; serious problems arise only when excess nitrogen loads reach the oceans. Nitrogen trading therefore opens up the possibility for trading within considerably larger geographic areas than present trading schemes recognize.

With the development of Internet market places like NutrientNet, the potential for more widespread adoption of nutrient trading seems likely.<sup>24</sup> The NutrientNet website is designed to give agricultural nonpoint sources of nutrients a first-cut estimate of their nutrient contribution to a watershed, the likely reductions they can achieve through adopting a variety of mitigation options, and the cost of implementing nutrient reduction activities. Similarly, point sources can make an initial estimate of the costs associated with reducing their nutrient emissions. In addition, buyers and sellers of nutrient credits can post their offers on the website, providing a centralized market for trading to occur. Finally, trades can be registered and tracked for greater transparency and monitoring of trading activities.

Water quality improvements have also been tied to other environmental benefits. In an analysis of climate change strategies for United States agriculture, for instance, nutrient trading provided significant reductions in greenhouse gas emissions and in soil loss, in addition to water quality benefits.<sup>25</sup> The synergies between environmental goods and services are reason enough for developing comprehensive strategies to address environmental problems.

With environmental policy moving away from traditional command-and-control approaches and toward more market-based incentives, trading can provide a unique cost-effective solution to many water quality problems. Trading can reduce the cost of compliance by industrial and municipal facilities to meet increasingly more stringent water quality standards, it allows unregulated sources of

pollutants such as agriculture and urban nonpoint sources to be part of the solution, and it improves water quality.

Among the various policy options available, trading is potentially the most effective, as it provides a win-win solution for regulators, industrial and municipal facilities, agriculture, and society as a whole.■

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# Treading Political Water

*Political partnerships backed by sound science helped muster support for new legislation to protect Tennessee's water supply.*

BY DAVID LEWIS FELDMAN

Over the past two decades, conflicts over water supply have erupted throughout the Southeast. Three trends have fueled these disputes. First, users of the same watercourses and aquifers compete for the same resources. Second, land-use patterns are changing, population is growing, and regional climate is affecting supply. Third, it is becoming increasingly difficult to balance economic growth against demands for a high-quality water supply.<sup>1</sup>

Tennessee is a microcosm of these trends and faces several threats. Of vital importance to agriculture, industry, transportation, energy production, recreation, and the environment, Tennessee's water is a finite and increasingly threat-

ened resource. Recent drought, population shifts, urban development and sprawl, and growing competition among users has raised concerns over the continued availability of a stable, dependable water supply. In addition, the state's water has become the focus of interstate conflicts.

While water supply is generally plentiful statewide, regional variations in demand are significant. Eastern Tennessee, for example, uses 2.5 times as much water as middle Tennessee and 24 times as much as western Tennessee, largely because of electric power generation. Moreover, while surface-water use predominates statewide, groundwater constitutes 89 percent of the water used for nonpower purposes in western Tennessee, and half the state's popu-

lation in its western-most quarter relies on groundwater for drinking water. In addition, highly consumptive uses, such as agricultural irrigation are increasing.<sup>2</sup>

Periodic drought is also a threat. From 1985 through 1988, when precipitation statewide was 75 percent of normal and streamflow half of normal, serious declines in water quality occurred leading to emergency measures to allocate and conserve, including local bans on nonessential uses.<sup>3</sup> Despite these problems, a survey conducted by the Energy, Environment and Resources Center at the University of Tennessee in 1999 suggests that users are resistant to rationing or withdrawal permits. Respondents favored better planning and contingency plans to manage water supplies during periods of drought.<sup>4</sup>

Interstate disputes are also increasing in frequency and intractability. Georgia, for example, is in the throes of a water war with Alabama over how to share water from the Alabama-Coosa-Tallapoosa basin and with Alabama and Florida over the Apalachicola-Chattahoochee-Flint basin (See "Thirst for Growth" in this issue of FORUM). Two compacts, ratified by Congress in 1997 and scheduled to take effect once the three states agree on an allocation formula, would place verifiable limits on Georgia's ability to draw water from both basins. Atlanta might also have to look elsewhere for water sources to satisfy growing needs.

Among the possible options the city was said to have considered was a plan to purchase water from Chattanooga's municipal supplier, the Tennessee-American Water Company, and divert it via pipe-

line. This prompted concern in Tennessee that the state's water supply was vulnerable to outside demands, it exacerbated tensions between the city of Chattanooga and Tennessee-American—who were already feuding over water rates—and it led to concerns over how Georgia can rightfully draw water from the Tennessee River.<sup>5</sup>

Meanwhile, Memphis, one of the largest cities in the world to rely on groundwater for its supply, faces potential conflict with Mississippi. The city's water is provided by a publicly owned municipal utility—Memphis Light, Gas, and Water—whose wells tap into the Memphis Sand Aquifer, a reservoir underlying nearly 7,400 square miles (19,000 square kilometers) of western Tennessee and parts of northern Mississippi, southwestern Kentucky, and eastern Arkansas. While the utility is the largest user of the aquifer, DeSoto County, Mississippi, is growing rapidly and views the aquifer as a potential future supply source. It is possible that nearly one-third of Memphis's water supply from the aquifer is withdrawn from beneath DeSoto County. This has led to calls for better understanding of the aquifer and pursuit of a more regional approach to its management.<sup>6</sup>

### **Tennessee Acts**

Growing awareness of threats to the state's water supply led to legislative action by the state of Tennessee. In May 2000, Tennessee's General Assembly passed, and the governor signed, a historic law requiring the state's public water providers, whose rights are secured by eminent domain, to acquire a permit for surface or groundwater withdrawals diverted outside their

basin of origin that “have a significant potential to adversely affect the flow of a Tennessee surface water body.”<sup>7</sup> The Inter-Basin Water Transfer Act provides authority to protect streams subject to low flow, bolsters rights of riparian users, regulates water quantities diverted and returned, and mandates consideration of potential alternatives to interbasin diversion.

Public providers must also register annual withdrawals, and the state has powers to protect deficit-ridden areas from diversion. Furthermore, the law divides Tennessee into 10 catchments—natural water basins defined by the drainage of major rivers and streams on a land-surface area—for planning purposes. Designation of these catchments and other aspects of the law were objects of lengthy negotiation.

Tennessee's new act represents a change in its policy agenda in response to perceived threats and new evidence of the vulnerability of the state's water supply. The sources of this policy change, the genesis of the new law, and the role of stakeholder and legislative negotiations in its passage can provide important lessons for policymakers in other regions.

### **Genesis and Evolution**

Six states bordering Tennessee—Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia—have already adopted measures to protect water supply through a combination of approaches, including registering withdrawal of surface and groundwater, managing drought by requiring minimum stream flows, permitting large withdrawals, and regulating interbasin diversions.

In early 1999, Tennessee's Department of Environment and Conservation asked the University of Tennessee's Energy, Environment and Resources Center to assess present and foreseeable water supply problems, examine case studies of potential conflict, and explore possible legal remedies similar to those adopted by other states. The report recommended taking into account regional variations in statewide water use, fostering greater cooperation among communities in planning their water supplies, and strengthening existing water rights through instituting permits for interbasin transfers. Almost simultaneously, talk of increasing diversions from Tennessee to northern Georgia as well as a proposal to tap into the Cumberland River to provide water supply for communities in Kentucky gave added impetus to demands for new legislation, which the Energy, Environment and Resources Center helped draft.

Drafting and securing passage of the Inter-Basin Water Transfer Act faced five major hurdles. First, except for drinking water, water supply was largely unregulated in Tennessee. Just one state law regulates in-stream volume, but its powers were limited to preventing physical or chemical stream alterations that threaten aquatic habitat.<sup>8</sup> Second, many key concepts in the draft bill had to be clearly defined to placate affected interests, for example, the terms *basins*, *public water providers*, and *significant harm*.<sup>9</sup> Third, some groups initially opposed any new regulation affecting utilities that already transfer water out of a water basin and those that envision economic gain in new out-of-basin transfers. Fourth, there was little time to

educate legislators or to negotiate with those who might be affected by the legislations. Like many state legislatures, Tennessee's meets only part of the year. A bill had to be introduced early in the session, mid-February, to ensure passage by session's end in June. Finally, a law regulating water supply must treat in-state and out-of-state uses consistently or federal courts might rule that it violates the U.S. Constitution's commerce clause. Thus, a means had to be found to regulate interbasin diversion without discriminating against out-of-state users. This was done by requiring permits for all transfers out of a basin within Tennessee regardless of whether the diversion's source originates in or outside the state.

Three strategies helped surmount these challenges: increasing the bill's transparency in negotiating with key interest groups, placating legislators' concerns, and making sure influential news media were familiar with the issue.

Key sponsors in the legislature and some lobbyists representing powerful interest groups that would be affected by the bill acknowledged that the bill could bolster the rights of existing users through rule-making rather than litigation. They also recognized that it would create a level playing field for future interbasin transfers and that it would strengthen the state's authority over water supply. Nevertheless, they insisted that key concepts be made more transparent within the bill's text before they would support it. Moreover, they did not want to wait for this clarification to occur in the rule-making phase that follows a bill's passage but precedes its implementation.

Key demands included grandfathering existing transfers and

designating the actual catchments for purposes of permitting. Tennessee's Department of Environment and Conservation's solution was to divide the state into 10 basins and allow key interests, such as public utilities that already provide water outside their own basin, to offer slight adjustments to their boundaries in accordance with established water use patterns. Prior to approving grandfather transfers, the U.S. Geological Survey assured Tennessee's Department of Environment and Conservation that existing transfers posed no serious problems.

Finally, environmental groups suggested that permits be renewable every five years, and those seeking new interbasin transfers must consider alternatives. These compromises alleviated the concerns of most vocal interests. Until the very end, however, lobbyists for one water utility interested in promoting out-of-state water sales sought to weaken the bill's language.

### **Navigating Political Waters**

Another strategy to gain support for the bill was to enlist bipartisan support. Key leaders from both parties cosponsored the bill in the House of Representatives and Senate. Two of these represented the Chattanooga area, which could be directly affected by proposed water transfers from the Tennessee River to Atlanta. Bipartisan support made passage more likely, especially since legislative sponsors held senior rank. There were other hurdles, however. While Democrats generally viewed the bill as good policy, they preferred stronger legislation that would protect particular regions, such as the Cumberland Plateau, as well as the

state as a whole. Some of the bill's amendments were concessions to these concerns. One amendment requires registration of all public withdrawals to provide a benchmark against which water-transfer impacts can be assessed, and Tennessee's Department of Environment and Conservation can forbid diversion from over-stressed areas of the state.

For their part, most Republicans were pleased that business interests did not oppose the bill and that the governor, a Republican, favored it. Both parties were assured, meanwhile, that permitting costs and economic burdens would be nominal. The task of gathering together supporting information for permits would be the responsibility of utilities, the costs passed along to consumers would be small, and costs to the state to process each permit would range from \$10,000 to \$15,000.

Finally, the University of Tennessee's Energy, Environment and Resources Center study proved useful in helping convince legislators of the value of, and need for, a new law. Two of the study's findings were especially cogent: first, that more vigorous enforcement of existing state law would not afford protection against potentially harmful diversions and, second, that neighboring states already had some means of regulating interbasin transfers.

Yet political maneuvering alone might not have assured passage of a bill that covers complex legal and environmental ground. It was also necessary to educate the legislators and the public they serve. Nashville and Chattanooga newspapers, as well as one statewide journal—the *Tennessee Farm Bureau News*—discussed possible threats that

made the bill's passage beneficial, and these and other media endorsed the bill's passage. Administration officials cultivated close connections with key reporters across the state and offered access to detailed information on water supply issues and story angles. Moreover, the administration saw to it that these stories and editorials were circulated among legislators. Though knowledge about the issue was initially low among the public and legislators, media coverage appears to have heightened interest in it. For example, during one-on-one meetings and in committee debate, legislators referred to editorials or news articles they had read. In the end, the bill prevailed unanimously: 29-0 in the Senate and 96-0 in the House.

#### **Timing...and Hard Work**

Sound science and policy analysis provided by the Energy, Environment and Resources Center report and other sources such as the U.S. Geological Survey were useful but insufficient to ensure the bill's passage. The law passed thanks to a combination of favorable circumstances and savvy politicking. Three circumstances kept legislators' attention focused on water supply issues: media coverage of the tri-state water wars, the potential for Atlanta buying Tennessee River water, and the region's recent drought.

Most important, supporters took advantage of this situation by demonstrating that a potentially serious problem existed and that other states had already taken action. They also established the

need for the law by showing why existing regulation was not fully protective. Supporters persuaded key interests of the importance of the bill by clarifying legislative intent, thus making the bill more transparent. Key amendments that strengthened the bill, and assurances that implementation costs would be small, helped garner bipartisan legislative support. Finally, the issue was packaged in a way that made it likely that citizens would embrace the law. Media coverage framed the issue by making the adverse impacts of unregulated interbasin transfers understandable.

Those interested in protecting water supply in their own region can take home one key lesson from Tennessee's experience: state legislators are most likely to take action when a proposed bill responds to a genuine problem for which current legal remedy is inadequate, and which is crafted to be acceptable to key interests.<sup>10</sup> ■

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#### **NOTES**

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the USGS, NASA, and NOAA (August 1997).

2. S.S. Hutson, *Water Use in Tennessee, 1995* (Nashville, TN: U.S. Geological Survey and Tennessee Department of Environment and Conservation, 1998).

3. A.B. Hoos, "Tennessee Stream Water Quality: National Water Summary, 1990-1991," Water Supply Paper 2400 (Nashville, TN: U.S. Geological Survey, 1992).

4. David L. Feldman and Jill Elmendorf, *Water Supply Challenges Facing Tennessee: Case Study Analyses and the Need for Long-term Planning*, prepared for the Environmental Policy Office, Tennessee Department of Environment and Conservation (Knoxville, TN: Energy Environment and Resources Center, University of Tennessee, June 2000).

5. Atlanta Regional Water Supply Plan Update, adopted December 3, 1997, Atlanta Regional Commission, unpublished report; K. Gilbert, "City Drops Water War, Proposal Vote Today," *Chattanooga Times and Free Press* (October 26, 1999), p. A-1.

6. T. Charlier, "Memphis Taps into DeSoto County Well Levels," *Commercial Appeal* (Memphis, TN, May 23), p. A1-9; W. Parks and J.K. Carmichael, *Geology and Ground-Water Resources of the Memphis Sand in W. Tennessee, Water Resources Invest. Rep. 88-4182* (Memphis, TN: U.S. Geological Survey).

7. Inter-Basin Water Transfer Act (2000).

8. Tenn. Code Ann. § 69-3-108(b)(4), 1997.

9. A basin is the area of land drained by a major river or stream. *Public water providers* are entities that acquire the rights to provide water to municipalities or other communities through eminent domain or condemnation. *Significant harm* consists of losses to current users or the environment.

10. This paper is adapted from a presentation at the 2000 meeting of the American Water Resources Association. Thanks to Dodd Galbreath and Alan Leiserson of the Tennessee Department of Environment and Conservation for clarifying the legislative process.



# Water Vision 2001

*A comprehensive regional approach to water policy offers the best hope for addressing our water needs in the new millennium.*

BY EARL BLUMENAUER

While the 20th century taught us that many of our environmental problems are interrelated and require integrated solutions, we still have much to learn and a long way to go. We have all too often failed to see that problems of water supply, water quality, and flood control, for example, are related to sprawl, traffic congestion, and air pollution. Consequently, we have failed to understand that these problems demand comprehensive, regional solutions—not piecemeal, local ones.

Consider, for instance, the case of metropolitan Atlanta, where rapid, unplanned growth has led to horrific traffic congestion, the nation's longest average commute, and some of the nation's worst air

pollution. Efforts to ease congestion through more road building, however, have led only to more traffic and more air pollution. The air pollution in Atlanta is now so bad, in fact, that the federal government has withheld funding for highway construction within the city.

The region's waters have also suffered. Road building has eaten up wetlands and precious open space, which retain and purify water. Today, metropolitan Atlanta loses up to 50 acres (20 hectares) of green space a day to pavement, and over 60 percent of the region's rivers and streams do not meet federal water quality standards.

Atlanta is not alone, of course. Water problems abound throughout our nation:

- Despite federal flood-control spending of over \$40 billion since

1960, flood losses top \$4 billion annually—triple the annual real losses of the early 1950s.

- Over half the wetlands in the continental United States have been lost—decreasing the natural capacity to filter water and prevent flooding.

- Some 40 percent of the nation's lakes, rivers, and streams are polluted and unfit for drinking, swimming, or supporting aquatic life.

- Agricultural runoff contaminates 60 percent of the nation's rivers and streams.

- America's cities, towns, and villages face an estimated \$20 billion annual funding gap for water and sewer systems over the next 20 years.

Sadly, government policies force us to approach water management in an inefficient, piecemeal fashion. We cannot afford to continue this approach; water needs are quickly outstripping available supply. Government funds and programs at the local, state, and federal levels are simply not up to the task. Local and state governments have no authority or capacity to deal with water problems that cross political boundaries, while federal regulations do not allow for innovative water-management strategies that could address our needs in a cheaper, greener manner.

Consequently, we cannot guarantee clean drinking water, flood protection, recreational waters, nor critical wildlife habitat—despite the billions of dollars we have invested.

We deserve better and we can do better. Using existing governmental powers and current revenues, we can begin to craft integrated solutions that improve water supply, restore water quality,

prevent floods, and sustain wildlife. The key is to manage our water resources regionally, at the watershed level. This is the premise of Water Vision 2001, an approach that incorporates four critical elements:

- Enacting a Water ISTEA,
- Reshaping the Federal Flood Control Program,
- Reforming the National Flood Insurance Program,
- Strengthening the Coastal Barrier Resources Act.

### **Water ISTEA**

Many of the same issues that confront water policymakers today—limited funding, problems that cross political boundaries, and lack of flexibility—vexed transportation planners for years. Finally recognizing that transportation problems could not be solved one municipality at a time, Congress passed ISTEA (Intermodal Surface Transportation Efficiency Act) in 1991. With innovations such as systemwide planning, federal funding flexibility, and a requirement for meaningful citizen participation in regional transportation decisions, ISTEA provided the tools state and local governments needed to create more-effective regional transportation systems. More than a specific piece of transportation legislation, ISTEA initiated a new concept, one that promoted planning-friendly approaches that encouraged governments at all levels to work creatively and collaboratively to address longstanding problems. It met with resounding success.

In 1998, building on the success of the ISTEA model, I introduced House Concurrent Resolution 86a in Congress to create a "Water ISTEA." Its goals are to in-

corporate those same principles of regional planning, federal flexibility, and meaningful citizen participation into a federal approach to regional water management.

**Regional planning.** A Water ISTEA would recognize the efficiency of regional, rather than local, planning for water resources. Instead of tempting cities and states to deal with water problems merely by shifting them downstream, federal programs would encourage local governments to develop regional partnerships and basinwide water management plans. As in ISTEA, federal funding would be predicated on the adoption of regional management plans.

To illustrate the benefits of a regional approach, let me provide an example from my own experience—one that is, I'm afraid, not unique in our nation. As the city commissioner in charge of Portland's sewer agency in the 1990s, I was frustrated that federal regulations discouraged the city from crafting a regional approach to managing the pollution problems of the Willamette and Columbia Rivers. Once completed, the city of Portland will have invested \$1 billion to eliminate rain-induced sewer overflows into these rivers, yet runoff from farms, golf courses, and construction sites upstream continues to foul our waterways.

If we had been able to use part of our cleanup dollars to address upstream problems, instead of focusing only on local, isolated fixes, we could have enlisted state agencies, rural communities, and citizens along both rivers in a partnership to craft comprehensive solutions to nonpoint-source pollution. Such an approach would have improved water quality over many more river miles and would have

forged greater city-state working relationships. Not incidentally, a "cheap and green" approach would also have educated, activated, and empowered citizens to become better stewards of a treasured resource.

Regional approaches are also critical for effective flood control. The abundance of federal funds for levees and dams has encouraged local governments to employ inefficient, isolated fixes to problems that extend far beyond local boundaries. Levees and dams may limit local flooding, but they usually exacerbate flooding problems in downstream communities. And when floodwaters spill over our best dams and levees, as they inevitably do, even greater damage accrues to peoples' lives and livelihoods. Our overreliance on these expensive structures has lulled millions of people into building and living in harm's way.

Tragic events along the Mississippi River in the past decade clearly illustrate the folly of local flood-control strategies. The Mississippi River between Minneapolis and St. Louis is a complex network of 60 flood control reservoirs, 1,600 levees and 29 locks. In 1993, this watershed experienced its wettest spring in 99 years, causing floods expected only every 100 years, or, in some places, every 500 years. These floods were devastating. Nearly 26,000 people were evacuated, 56,000 homes were damaged, more than 250,000 people were without drinking water for 19 days, and 50 people were killed. All told, the damage costs came to \$15 billion.

Since then, mitigation efforts have been sought to reduce future flooding impacts. Approximately \$212 million was spent to relocate

11,610 at-risk properties. These investments have paid off. In Arnold, Missouri, for example, damage from flooding dropped from \$2 million in 1993 to \$40,000 for a comparable flood in 1995.

Finally, flood control projects can degrade the environment by concentrating flows, preventing natural filtration processes, and causing downstream erosion. They severely limit the amount of water needed for wetlands, and they increase downstream erosion. Additionally, flood controls generally alter the natural landscape, disrupt critical food chains, and disturb natural filtration mechanisms.

Viewed regionally, the benefits of alternative approaches to flood control—such as reserving floodplains and wetlands for river overflow—become clear. Federal subsidies for large-scale flood-control projects, however, skew the local decision-making process in favor of available funds, rather than long term effectiveness.

**Federal flexibility.** Unfortunately, once communities begin to address water-cycle management from a regional perspective, they find themselves stymied by highly structured federal programs and regulations. Over 20 federal agencies have programs that fund water projects or regulate water use. Yet most limit the way funds may be used and prohibit combining funds from multiple sources.

Water ISTEA would allow communities to decide what kinds of projects best suit their needs. At the very least, communities must be allowed to combine funds for projects that meet multiple objectives. For example, the Department of Agriculture's Crop Reserve Program can be used to reclaim wet-

lands adjacent to a river, while the Federal Emergency Management Agency's pre-disaster mitigation funds can be used to move houses from frequently flooded river banks. Why not combine these funds, since both programs seek to keep humans and their infrastructure out of harm's way while restoring a river's ability to nurture important wetlands? Regulations should also allow for flexibility. Standards must be maintained, but latitude should be granted in how they are achieved. Recognizing the potential for such an approach, the U.S. Environmental Protection Agency created the Excellence in Leadership program in 1996 to provide regulatory flexibility in exchange for improved environmental results.

**Meaningful citizen participation.**

Everyone affects the water cycle, and everyone—particularly taxpayers—can benefit from innovative, regional water management. People care about clean water, wildlife habitat, and flooding, and they want to be part of the solution. A Water ISTEA would help achieve those goals by supporting and expanding programs such as FEMA's Project Impact, which provides funding and education for local communities to learn how to prepare themselves for potential disasters. Allowing educated, committed citizens to become part of the decision-making process always results in better long-term solutions.

**Federal Flood Control**

The U.S. Army Corps of Engineers spends upwards of \$1 billion a year building and repairing flood-control projects. Instead of reducing flood losses, however, some projects can actually increase the

potential for flood damage. Some projects encourage high-risk development in flood-prone areas, reduce incentives for effective state and local floodplain management, and eliminate the natural and beneficial functions of floodplains.

To address this problem, I introduced H.R. 1186 to amend the Corps' Flood Control Program. The bill changes the cost-benefit and cost-share formulas that drive the program, making it possible for communities to use federal funds to preserve floodplains and keep development away from rivers and lakes. The elements of the bill were passed as part of the Water Resource Development Act of 1999. Now, communities and the Corps can do the right thing for the environment without paying penalties for archaic funding formulas.

**National Flood Insurance**

FEMA is required to provide federally backed flood insurance, even for properties in high-hazard areas that suffer storm damage over and over again and receive government payouts each time. These repetitive-loss properties make up only 2 percent of all properties covered by National Flood Insurance but claim 40 percent of all federal flood insurance payouts. During the past 18 years, repetitive losses have cost taxpayers more than \$2.5 billion.

Consequently, Congressman Bereuter of Nebraska and I introduced H.R. 2728 to make the most of flood insurance payments. Policyholders who file two or more claims that, together, total more than the value of the property, and who refuse to relocate or floodproof their property with federal assistance pay the full actuarial costs of the insurance—that is, they pay

the cost of the insurance that is not subsidized by the flood control program.

### **Coastal Barrier Resources Act**

Since its creation in 1982, the Coastal Barrier Resources Act has saved taxpayers approximately \$11 billion by withholding federal flood insurance and infrastructure subsidies from developments on millions of acres of coastal land that is prone to flooding and hurricanes.

Lost in much of the debate about the costs of subsidized flood insurance, however, are the ancillary costs of development. When cheap flood insurance enables a developer to build in a high-risk area, roads, sewage-treatment plants, utilities, public buildings, and other infrastructure follow. The federal taxpayer bears the brunt of replacing this infrastructure after a storm. In fact, over the past 25 years, the federal government has spent \$140 billion of the taxpayers' money preparing for, and recovering from, natural disasters. Were it not for the Coastal Barrier Resources Act, that price tag would have been much higher.

In addition to saving money, this act has protected fragile coastal ecosystems and human life by discouraging those who would build on

lands vulnerable to recurring disaster. People who choose to take the risks of living there should assume the full financial costs of their choice.

Given limited funds and many other important national spending priorities, the Coastal Barrier Resources Act should be model legislation. Unfortunately, the act is being subjected to death-by-a-thousand-cuts as each Congress produces another set of technical corrections to remove land from the Coastal Barrier Resources Act system and entice developers with promises of federal subsidies to build on fragile and dangerous lands.

For example, H.R. 4070, introduced in the 106th Congress, sought to delete 280 acres of land from the protection of the Coastal Barrier Resources Act system—the largest single deletion in its history—and provide subsidies for development in the hurricane-prone Florida Panhandle. If this legislation is reintroduced and passed in the 107th Congress, it will rightly be seen as a brazen grab at taxpayer dollars, and if it succeeds, it will open the floodgates to other developments in equally hazardous locations. Instead of continuously eroding the protections provided by the Coastal Barrier Resources Act, we should be extending those same

protections to the rest of America's wonderful and fragile shoreline.

### **Public Interest**

Water respects no political boundaries; it follows the topography of our landscape. It is a regional resource, requiring regional solutions. Unfortunately, the federal government has not always fostered—and has often interfered with—efforts of local governments to work together for regional solutions. A Water ISTEA would change that by making the federal government a partner in regional efforts to provide effective water management. Indeed, a Water ISTEA could pick up where the transportation ISTEA left off, providing even more examples of regional cooperation to solve longstanding and complex problems. It could provide a sound framework for our metropolitan areas to address the environmental challenges of the 21st century. It could also provide Congress with a rare opportunity: the chance to debate not just how much money to spend, but how to spend money to get the best results. I can think of no better definition of the public interest than that.■

*Earl Blumenauer is a U.S. congressman from Portland, Oregon.*

# Watershed Events

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# Pioneering Solutions

In the early days of the American West, the U.S. government encouraged allocation of water resources on a first-come, first-served basis and promoted development with disregard for the environment. It was the rare observer—like explorer, geologist, and ethnologist John Wesley Powell—who could see the big picture. Powell advocated developing the West along “hydrographic basin” lines that transcend political boundaries.

Today, a water-basin approach to managing water is finally making inroads with policymakers in the United States. “A watershed’s upland flora and fauna, biotic integrity, riparian area, stream structure, and hydrology are a single system in nature,” says the Bonneville Environmental Foundation’s Angus Duncan. “Disconnect the parts and the whole unravels.”

Watershed science can serve as a kind of referee for competing interests guarding their own territory. We need to find an alternative to the fundamental mismatch between current institutions of river governance and the ecology of watersheds, Duncan says

Governors of Maryland, Pennsylvania, and Virginia, along with the mayor of Washington, D.C., the Chesapeake Bay Commission, and the administrator of the U.S. Environmental Protection

Agency, have taken a giant step in that direction with a new interstate agreement: *Chesapeake 2000*.

The Chesapeake Bay is the largest estuary in North America, but ever since Captain John Smith described the bay in the early 1600s, its health has been in a steady decline, say Geoff Oxnam and John Page Williams of the Chesapeake Bay Foundation.

Over the years, the bay’s waters have received multiple insults, including household waste, industrial pollution, agricultural runoff, and sediment pollution from development. Since its inception in 1967, the Chesapeake Bay Foundation has advocated state and federal response to the decline of the bay and spearheaded research and environmental outreach programs. Still, the bay is just barely holding its own. One of the most dire threats is harmful sprawl, which gobbles up open land in the watershed and increases the load of effluent entering the waters. *Chesapeake 2000* aims to reduce the rate of conversion of land for sprawl and preserve 20 percent of the land area of the watershed.

While watershed management may seem like an idea whose time has come, the Tennessee Valley Authority has been treating the Tennessee River and its tributaries as a single unit for over six decades, say Jack Davis and colleagues with TVA. From the start, in the 1930s, TVA has aimed to realize the full potential of the Tennessee River and its tributaries. To that end,

TVA operates its 49 dams as a single unit balancing multiple uses, from navigation and flood control, to recreation.

TVA operates two types of dams, one on the river’s major tributaries to regulate seasonal flows of water, another on the main channel of the river, primarily for navigation. Moreover, TVA allows a good deal of flexibility in its day-to-day operations to respond to variations in streamflow and rainfall. Finally, TVA’s integrated system balances competing demands to support navigation, flood control, recreation, fishing, aquatic habitat, waste removal, and thermal cooling.

Ironically, at a time when population growth and economic development are sparking water wars even in water-rich regions, the integrity of the TVA system is being challenged. Several scenarios have been proposed, including splitting its responsibilities among several agencies or even privatization. To dismantle a successful and productive model would result in a waste of water and money, the authors say. Instead, TVA’s integrated approach to river management should serve as a model for other regional watersheds coping with conflict over allocation of scarce water resources.

*The Editors*



# Of Time and the River

*The government agencies responsible for managing our western rivers need to better align their activities with ecosystem values.*

**BY ANGUS DUNCAN**

**W**ater has been stored, channeled, drawn off, and moved about from one place to another across the western landscape for the past 150 years. The hydrographs of western water basins have been modified by the western impulse to manipulate, remake, or shift from one place and time to another until parts of some river beds are dry by midsummer, while plains that used to bake in the heat are now flooded and green, producing goods for world markets. Low-gradient mountain valleys that once were beaver backwater and camas marsh have been drained and diked and planted with mint and alfalfa. Snowmelts and spring floods that defined millennia

of aquatic biota in western watersheds define them very differently today—their waters impounded and held for summer irrigating or shifted forward into the following winter to meet electric power demands. Slackwater pools behind New Deal dams are sluggish and warm, creating habitat for differ-

ent species than those evolution introduced and nurtured for thousands of years before.

The litany of changes in the reports from different western watersheds has familiar texts and cadences. Collectively, they describe the development model that has been used to shape and manage

all western water basins. Finite water supplies have been managed—and consumed—on a presumption of abundance. The effects of direct consumption of water have been compounded by indirect consumption—degraded water quality caused by modifying water temperatures, chemistry, sediment loads, stream beds, riparian and upland structure, and timing of flows. Biological effects of physical stream alterations, in their turn, have been compounded by direct harvest of species with commercial value—beaver and salmon among others.

National and western values now call for redress of these effects, for a recovery of threatened and endangered species and the concomitant rehabilitation of watershed habitats. The emerging science of

stream ecology teaches the significance of complexity, diversity, and sufficiency in biological systems and in the hydrology and topography of streams and adjacent lands. But development pressures on western waters have not abated despite a growing recognition of scarcity and over-allocation. Demand for some uses, such as irrigation and recreation, has intensified in ways that reinforce the developed status quo and hamper watershed restoration.

Calls for environmental protection could once be met in a fashion that seemed to satisfy all parties: protect a little more land or water in a wilderness area, add irrigation storage capacity downstream, insert a fish hatchery to offset losses of productivity in natural habitat.

Easy solutions are more elusive today, however. With much of the available watershed resource already committed to commercial use and demand not slackening, we must divide up a shortage while reserving—or reclaiming from present users—enough of the watershed to restore it to sustainable levels of biological health and ecological integrity.

Can we do this with the tools available—laws, agencies, institutions—almost all of which are legacies of the development model? Or are the tasks sufficiently different that new river governance models and institutions must be devised?

### **Institutional Legacy**

**T**he visible tools of the development model are prior appropriation of water rights, allowable cut of timber, harvest allocation of fisheries, animal unit months,<sup>1</sup> and hydropower licensing. Less direct,

but equally significant, are land use and zoning laws, transportation strategies, subsidies, and tax incentives, all of which encourage economic development of natural resources without a corresponding concern for environmental outcomes. These are all expressions of the development model that has governed the West since Euro-American settlement began. Each

water or land or mining claims. Because its object was to promote development, it required the beneficiary to use the resource or lose it to someone who would. So, today, western states struggle to find a basis in water law that would sidestep this principle and allow unused—“wasted”—flows to be left in-stream, rather than be reallocated and permanently lost to

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## **The emerging science of stream ecology teaches**

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### **the significance of complexity, diversity, and**

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### **sufficiency in biological systems.**

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represents a pragmatic solution to a need particular to a place and time, and each was usually well suited to the need when it arose.

Prior appropriation as a basis for securing water rights, for example, emerged in California’s mining camps, where it provided an elegant, equitable basis for allocating water among multiple claimants. When the problem is stated narrowly—how to distribute limited supplies of water, in some cases remote to the miners’ claims, in a way that will be respected as fair by all parties—the tool fits the task. It is only later, when the statement of the problem is enlarged with other considerations—preserving the biological health of the streams, for instance—that the pioneer solution becomes a status quo impediment to solving the newly stated problem. The tool wasn’t constructed to protect stream health. It should come as no surprise that it is unable to do so.

The development model relied heavily on the principle of first-come, first-served, whether for

junior appropriators with claims to it supported by history and principle.

Unfortunately, the agencies today that have conservation responsibilities rely on the Progressive Era definition of conservation as a tool to sustain harvest. Their best tools are designed for extraction, not the protection of ecosystems.

There is a fundamental mismatch between human institutions geared to efficient consumption and ecosystems existing in an equilibrium that may be disturbed from time to time but that requires most of its parts most of the time.

Human consumption can permanently disrupt ecosystems by directly harvesting species to extirpation, by simplifying genetic diversity to a point at which species resilience is lost, by displacing species from their essential habitat, or by so degrading the habitat that it can no longer sustain its natural biota. The institutions established in the West to facilitate development affected river

ecosystems in each of these ways.

Commercial demand for beaver pelts, buffalo robes, and canned salmon took their devastating toll on these species in the 19th century. Most western river ecosystems, however, survived frontier levels of consumption substantially intact. It was not until population levels rose, more efficient technology was devised, and eco-

Colorado River states jostle each other, the Upper Colorado states, and Mexico for increased shares of a declining resource. Discontinuities in management authority encourage a parochial competition to consume. The biggest consumer is rewarded with the largest permanent resource allocation, while modest appetites are penalized.

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## Coherent management of watersheds, whether for efficient consumption or conservation, is hostage to political boundary lines drawn on maps.

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conomic development was systematically supported by government laws, investments, and subsidies that habitat degradation and biological re-engineering began to take their vastly greater toll.

### Boundaries

**M**ore than a century ago, John Wesley Powell advised us to organize development of the West along “hydrographic basin” lines. But state and local boundaries were set at the convenience of commercial and political interests, indifferent to Powell’s advice. Upper basins are divided from lower ones, and left banks from right. Rivers that should have been the unifying spines of states are their dividing lines instead.

Coherent management of watersheds, whether for efficient consumption or conservation, is hostage to these lines on maps. Water conserved in Oregon to augment Snake River flows, for example, may be withdrawn by an Idaho farmer across the river. Lower

Other lines divide watersheds. National forests are oriented to ridgelines, since that’s where the harvestable timber exists. Two or more Forest Service planning units may share jurisdiction in a single watershed with Bureau of Land Management grasslands and with private holdings in stream bottoms governed by state and local land use laws.

We have even interposed a boundary line between surface and subsurface waters, allowing us to manage and allocate waters and riparian areas as though they were quite unattached to each other. This distorts our understanding of the hydrological cycle in ways that advantage some water users while degrading the hydrological basis of the river ecosystem. Detaching streams from their floodplains elevates stream temperatures, increases channelization, reduces sanctuary from predators, damages food webs, and generally diminishes the ecosystem diversity on which the stream’s biota rely.

Boundaries lend superficial credence to notions like “waters of the

state,” as though the hydrological cycle does not move water across state lines. Yet there has come to be a different kind of possession of rivers, a “hydrocommons,” that extends beyond the physical drainage to include all the users of a river basin’s products.<sup>2</sup> Interbasin transfers of water—most famously from Owens Valley to Los Angeles—are the most explicit example of extra-basin claims established by usage. Power generated on the Colorado River may be transmitted to Los Angeles or eastward to Arizona and New Mexico. Wheat from North Dakota is trucked to Lewiston, Idaho, barged downriver to Portland, and shipped to Japan. These uses are new economic claims that must be either satisfied by the river basin or backed out at some economic and political cost. Because they place demands on western rivers, they may diminish the basis for life in one watershed or ecosystem to enrich another as surely as if the water itself had been transported.

### Consumptive Policies

**F**ederal and state policies for the last century have been designed to accelerate development of the American West and the economic use of its natural wealth. The litany of grazing, mining, and other laws encouraging economic activity is well known. Powell was not proposing conservation set-asides in his hydrographic basins, but, instead, efficient and sustainable consumption, foreshadowing the Progressive Era model of conservation developed by Theodore Roosevelt and Gifford Pinchot.

A distinctive culture has been nourished and encouraged by these policies. Living wages have been produced for many, substantial wealth

for a few, and enviable communities for all, in which gracious and rewarding lives can be lived.

Both the benefits to human communities and the costs to other biota are products of conscious government policies to encourage development that relies on direct and indirect subsidies and public investments. While nature celebrates diversity, civilization values productivity, which in the short term means uniformity and homogeneity. A field of soybeans replaces the diverse flora and fauna of prairie grasslands; a tree farm replaces a forest. Stairstepping slackwater reservoirs are substituted for a turbulent, free-flowing, spring-flooding western river.

Government resource managers responded to the policy signals by adopting client relationships with their commercial counterparts. By serving a collective of private interests, the public interest would be served. And while the policy signals have become distinctly mixed with conservation messages in the past 20 years, the client relationships endure, maintaining the status quo and resisting pressure to change.

Subsidies are often just as firmly embedded and are slow to respond to changing signals. The subsidies can be as open as land grants and loans that are interest-free or freely forgiven. They can be subtle—power-at-cost for irrigators and aluminum plants. Or they can be obscure—reservoirs that lift and carry water nearer an irrigator's fields, at no charge.

Frustrated resource managers are given ambiguous agency mission statements that mix support of commercial activities with conservation. But agency budgets are often associated directly with the

commercial, income-producing side of the house. Fish and wildlife departments are supported by license fees, forest management is linked to timber revenues, and power marketing administrations are supported by power sales revenues. It is the courageous and usually short-tenured agency leader who will consistently act to reduce agency income.

these uses are at cross-purposes with each other; a certain amount of compromise and jostling for position mitigates this conflict. More difficult to offset is the incentive each user has to externalize costs to other users, or to the ecosystem. Thus the forest manager might be inclined to leave more trees in riparian areas if she knew this would result in stron-

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## **Frustrated resource managers are given ambiguous agency mission statements that mix support of commercial activities with conservation.**

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### **Fragmented Management**

**A** watershed's upland flora and fauna, biotic integrity, riparian area, stream structure, and hydrology are a single system in nature. Disconnect the parts and the whole unravels. Variety is integral to biological systems; fragmentation is inimical.

For supporting human consumption, however, each element is best managed separately and for a different purpose. Forest productivity is judged on a delivered board-feet basis. Fishery managers seek maximum landed pounds of salmon or number of angler days. Hydropower requirements are best served by water in the river, held in reservoirs for periods of maximum electric demand and managed to meet electric load curves in cities hundreds of miles away, while irrigated agriculture receives benefits from water taken out of the river and spread on fields, to return on a schedule not synchronized with power dispatchers.

The problem is not only that

ger salmon runs. If the consequence of her actions was not stronger runs, but more fish for downstream harvest, however, the incentive to leave more trees would evaporate.

Coordination of management goals and actions is difficult at best, even within a single user set. An Idaho-bound Columbia River salmon, for instance, may pass through more than a dozen fish management authorities on its return from ocean to natal stream, and many more land and water management regimes. What is the likelihood that all these institutions and regimes are in alignment?

The ill effects of fragmentation can be overstated, of course. Acknowledging the interconnectedness of all things can be a short road to paralysis. There are no bright lines between ecosystems; ecosystems exist only by overlapping and interacting with other ecosystems. Columbia River salmon travel from Idaho to international waters off the Aleutian Islands where they intermingle with fish from Russian East Asia.

Where does their ecosystem begin and end?

While ecosystems resist boundaries, people have to manage their interactions with the surrounding environment. To do so, they have to define the environment in segments small enough to be intellectually manageable. The challenge for national resource policy is to orchestrate local actions in ways consistent with broad ecosystem and landscape functions and to reorder antiquated national and state policies to conform.

### Ecological Balance

**B**y the last quarter of the 20th century, it had become clear that the Progressive Era conservation strategies of Theodore Roosevelt and Gifford Pinchot were succeed-

ing only in the narrow sense of stretching resources for harvest. These strategies grew more trees; they did not protect forests. The emerging science of ecology took a different approach; it taught that species and their life support systems are interconnected in complex linkages and feedback loops and that species survival was closely associated with species and habitat diversity.

Ecological science is generally accepted now as the best and most useful explanation of how extra-organism biological systems work. But there is always lag time between scientific understanding and modifying human practices and institutions to conform. Hence the uncomfortable middle ground that natural resource public policy occupies today, variously expressed

as *multiple use* of resources, *balance* between human consumption and the requirements of natural systems, or *equal* treatment for conservation of species and habitats.

Why not *balance*? First, while natural systems can handle concepts such as *equilibrium*, they do not tolerate *compromise*. And in natural resource management, balance is usually a code word for compromise. Unlike contests for budget shares or tax breaks, natural systems have thresholds that must be respected for species to survive. If summer stream temperatures are persistently at 80 degrees and fish mortality is pandemic above 68 degrees, splitting the difference does little good.

Second, in such contests, the status quo is the default outcome, unless a sufficient and affirmative

## STEPS TOWARD IMPROVED GOVERNANCE

- Give priority, not just equal, treatment to protecting ecosystem functions when competing against new or existing economic uses.
- Build collaborative management institutions and tools—as alternatives to litigation and other, narrower processes—that offer rewards, including access to decision making for parties that have been excluded in historical allocations of control.
- Consolidate agencies with overlapping missions, or integrate their activities along ecological lines that are congruent with watershed boundaries.
- Avoid further locking in of watershed uses—such as new water rights, unregulated access to groundwater supplies, Federal Energy Regulatory Commission relicensings, and habitat conservation plans—without testing the ecological effects. Any new rights issued should be subject to modifications to reflect new scientific findings.
- Increase access to resource decision making by non-traditional stakeholders, and educate all stakeholders in the teachings of ecosystem science.
- Shape an intermediating role for ecosystem science and scientists in decision making processes at all levels.
- Employ ecosystem science in habitat conservation and use and apply it as a conceptual frame of reference for measuring actions and consequences.
- Identify and seek to resolve inconsistencies between prevailing policies and practices on the one hand and ecological structure and functions on the other. For example, the government has separate regulatory regimes for water quality and quantity; these should be integrated.
- Create tools to facilitate, not just intrastate but basinwide, water transfers, and phase out subsidies that have outlived their usefulness.
- Transition and cushion communities facing especially harsh or precipitous change from historical circumstances.
- Develop predictable and durable sources of funding for watershed restoration needs. ■ AD

case for change can be made to political leaders. After 180 years of intensive river development, the status quo is not in ecology's corner.

Third, if humans are the judge and jury, human needs will carry more weight. That's why species with commercial or aesthetic appeal do better in these proceedings. Policies farsighted enough to account for the importance to human destinies of preserving natural systems would reinforce the argument for conserving those systems. But human needs tend to focus one or two generations ahead at most. Natural cycles, and the consequences of human interference in them, can extend far beyond this near horizon. Species extinction may be the outcome of a housing project that will be abandoned within 100 years, but the extinction is not recallable.

Fourth, in forums of public policymaking, arguments and effects that are imprecise, hard to quantify, diffuse over large expanses, or remote in time are valued less than the precise, the immediate, and the quantifiable. In economist's jargon, they are "discounted." The immediate consequences of shifting water flows away from power or irrigation use and back toward the natural hydrograph are higher costs and lost revenues to economic users. The benefits to the river ecosystem may not manifest themselves for decades, and then they may be hard to disentangle from the other variables that comprise the biology and hydrology of the river. Or they may not materialize at all, being compromised by economic demands such as a harvest elsewhere in the system.

At best, a management strategy

based on balanced use gives resource managers ambiguous and conflicting signals, placing them in unwinnable conflicts between conservationists and economic interests. While some parties prosper in such circumstances, leveraging ambiguity with political or economic muscle, most people—ranchers and farmers, environmentalists, forest managers, hydroelec-

tric engineers—are simply frustrated. Frustration fuels emotional debate, exaggerated argumentation, or demonizing of one's opposition. In the absence of cooperation and conscience, the river suffers.

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## **The greatest weakness of ecosystem science—**

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### **its imprecision—ultimately may be its greatest strength.**

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tric engineers—are simply frustrated. Frustration fuels emotional debate, exaggerated argumentation, or demonizing of one's opposition. In the absence of cooperation and conscience, the river suffers.

Growing acceptance of the lessons of ecosystem science has undermined the development model. Water quantity and quality standards that condition new water withdrawal rights are increasingly linked to a stream's biological health. Impacts on stream ecology may be employed to condition riparian and upslope land uses. Protecting species means protecting habitat, and a species' habitat may mean more than the adjacent field or even the feeding territory. Protecting steelhead trout habitat may mean intervening to reduce stream temperatures miles upstream of the steelhead's spawning beds. Protecting estuarine habitat may entail flow releases from dams hundreds of miles away. Federal and state protections are not so comprehensive as this to-

clusively that an unacceptable injury will be inflicted on aquatic species. Ecosystem science is rarely able to be so definitive or precise; the variables are too many and the time frames are too long, rather like meteorology and climatology. For that reason, and if the objective is to protect the minimum threshold conditions that support a species—or, better, a river ecosystem—the burden of proof will have to be shifted to those proposing economic uses. If the evidence is inconclusive, a margin of error is needed to protect the species. The more difficult the proof, the greater the margin of error must be.

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#### **The Best Available Science**

**T**here are two prevailing patterns for integrating science into policymaking, neither of them entirely satisfactory. The first comes through the interaction of competing views of biology and hydrology in the public forum of ideas. Sometimes these differences are expressed in disciplined and

structured ways, through journal publication and critique. No less often, selective views or partial findings are advanced by those whose interests are served by a kind of advocacy science. This abuse of science flourishes particularly where the available evidence can support probabilities but not certainties and where time horizons tend to be most spacious.

costs, such as decommissioning a dam to test migration at natural river levels, the tenets of adaptive management meet a resistance quite as immovable as the dams themselves.

Without abandoning the scientific method of hypothesis testing, are there other roles that science can profitably fill? There are, but they depend on scientists conquer-

comes a sort of common ground to which parties of differing views but good faith can repair. The more informed these parties become in what the science can and cannot tell them, the more they will find themselves curiously captive to that understanding, less free to engage in the polemical excesses of the uninformed. They will find themselves searching together for solutions within science's conceptual framework, and finding them.

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## Science that carefully preserves its independence

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### becomes a sort of common ground to which parties

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Climate change is one such area; ecosystem health is another.

The second approach relies on the principles of adaptive management. In the presence of scientific uncertainty, a hypothesis is stated and management strategies are rearranged to test the hypothesis. Results may lead to policy changes or to a refined hypothesis and further testing.

Adaptive management has been a useful but limited tool in rationalizing river basin management practices. Fragmented authority has meant that agreement either on a hypothesis or the protocols for testing it has been difficult to achieve. Responsible agencies may be reluctant to modify practices necessary to carry out the test. Where an outcome is the product of multiple ecosystem forces, isolating one variable and holding other factors constant is often not possible. Where effects may become apparent only over decades, agency commitments often erode. And where testing hypotheses may have large financial or political

ing their impulse to also become policymakers. Watershed science in service to public policy goals is most useful when it is independent of interests advocating one goal over another. Scientists must be truth-sayers and truth-testers, affirming or critiquing the evidence and interpretations without regard for interests affected, costs, or societal consequences, the latter of which are the province of policymakers.

A second role for science is to describe the conceptual framework within which public policy must operate. Science must describe how hydrological and biological systems functioned in a pre-modern world, how these systems have been modified, and what the consequences have been. Scientists must then tell policymakers, within explicit probability limits, the likely consequences of proposed remedies.

A third and perhaps most critical role for science is that of intermediation. Science that carefully preserves its independence be-

### Incremental Steps

**N**otwithstanding the entrenched resistance to governance changes and the preference for narrow solutions to immediate problems, there is still value to forcing the governance debate. Incremental changes will occur as a conscious effort to improve cooperation, deflect regulation, or grab control. Such changes are also the unintended consequence of technical fixes.

One of the reasons institutional change can be painfully slow is the fear of unilateral concessions that are neither matched nor returned. When adversarial parties are seeking the slightest advantage in legal and political leverage, it seems foolhardy to make gratuitous gestures and count on the other party not to take advantage. Yet in smaller watersheds where the interests are individuals—sometimes neighbors across a table—these gestures are being made and answered. Where expectations can be personalized instead of conveyed by lawyers and public relations consultants, it's harder to take advantage of someone and still show up for coffee at the corner grill the next morning.

Especially when people can use watershed science as a kind of referee and independent interpreter of the rules, they may discover common ground that leads to home-grown solutions. Pride of place also becomes a basis for trust and confidence-building.

It is far harder for large western water basins to build on personal relationships. Elections, changes in administrations, professional mobility, the impersonal nature of large institutions, and the law as an abstraction all interpose between people. But the use of science, and the success of unilateral small steps taken and repeated, should encourage parties to search out low-risk ways to emulate their colleagues in small watersheds across the West.

### **Bridging the Gap**

**S**o the best and final counsel is...to inch along? Incremental gains are the only practical gains? That's not a very satisfactory conclusion. The threats to the hydrological and biological sustainability of western waters are real and immediate. Change must come fast enough to rescue distressed food webs and disappearing species.

But change comes about at its own pace and in its own season. Evidence accumulates that old institutions and practices are no

longer serving us well, either to explain events or shape outcomes. Harvest management rules aren't delivering the expected volumes of trees, or fish, or healthy forests and streams; water allocation rules can't keep groundwater levels from falling or aquifers from collapsing.

Individuals discern these patterns sooner than do institutions such as government agencies or economic interests invested in the status quo. Small communities in sparsely populated watersheds have the advantage over more ponderous institutions like the Corps of Engineers.

Only in the late innings do most institutions recognize the growing body of evidence and respond. If there is an entrenched minority with a stake in the way things are, the pace of change can be slowed or even arrested for a time. Ultimately, institutions that resist become irrelevant and are left behind.

But neither we nor the many species most immediately at risk can afford this kind of sullen dallying. If we are persuaded that there is a fundamental mismatch between existing institutions of river governance and the ecology of watersheds, then we are bound to offer a plausible alternative, and we are bound to promote it vigorously.

This may have the welcome effect of accelerating the pace of in-

cremental change. But it can also prepare us for the eventful moment, the window that opens from time to time as personalities and political forces briefly align and allow momentous change to take place. In such a moment, the national park system was created; in another, the Endangered Species Act was adopted. At those moments, the opportunities are greatest for those who are prepared. ■

*Angus Duncan is president of the Bonneville Environmental Foundation, in Portland, Oregon.<sup>3</sup>*

### **NOTES**

1. One "animal unit month" is the amount of forage a 1,000-pound cow consumes in a month. The units are used by the U.S. Forest Service and the Bureau of Land Management for allocating grazing rights on federal lands.

2. See Gary Weatherford, *From Basin to Hydrocommons: Integrated Water Management without Regional Governance*, Natural Resources Law Center Discussion Paper Series (Boulder, CO: Natural Resources Law Center, January 1990).

3. This article is adapted from chapter six of *A Survey of Columbia River Basin Water Law Institutions and Policies*, 2 (Portland, OR: Northwestern School of Law of Lewis and Clark College, June, 1997), submitted by the Northwest Water Law and Policy Project to the President's Western Water Policy Review Advisory Commission.



# Saving the Chesapeake

*Cooperation among government officials, scientists, conservationists, and the public is helping to restore the Chesapeake Bay.*

BY GEOFF OXNAM AND JOHN PAGE WILLIAMS

As she looked out over the marsh, across Hooper Strait to Bloodsworth Island, Ann Swanson said, "I'm proud and troubled all at once." Swanson—who is executive director of the Chesapeake Bay Commission, a legislative body established in 1980 to advise the legislators of Maryland, Pennsylvania, and Virginia—was talking to a group of state environmental officials, scientists, and conservationists about the future of the bay.

It was a Friday morning in October 2000. We had gathered on the second-story porch of the Chesapeake Bay Foundation's Karen Noonan Environmental Education Center, at the southern tip of the Dorchester County mainland on Maryland's Eastern

Shore. We had caught our dinner the night before and had begun the morning early by bird watching and canoeing the marshes. Now it was time for some serious talk about the health of the Chesapeake Bay and the Susquehanna River, and about the provisions of *Chesapeake 2000*, the new Chesapeake Bay Agreement.

This voluntary pledge between the governors of Maryland, Pennsylvania, and Virginia, the mayor of Washington, D.C., the Chesapeake Bay Commission, and the administrator of the U.S. Environmental Protection Agency recognizes that piecemeal efforts differing from state-to-state will never protect and restore an ecosystem this large. The original agreement—which is now nearly 20 years old, although it was updated

in 1987—set common goals and a framework for achieving them. Though not enforceable by law, it has been the centerpiece of a remarkable environmental turnaround.

Swanson was the perfect leader for such a discussion. She headed the team that drafted the new agreement, shepherding it carefully over two years through public hearings and tough negotiations. She played key roles in several initiatives of earlier Chesapeake Bay agreements, including a ban on phosphate detergents. Her pride is justified, but she has a right to be troubled, too. The long drafting process, which included exhaustive public input, clearly highlighted the Chesapeake's problems. The bay's health is on a plateau, with progress slowing down after 15 years of modest improvements.

This is a critical year for the agreement, Swanson emphasized. Many of the bay improvements made to date have been the low-hanging fruit. Solutions to complex and politically charged issues, such as further reducing nutrient pollution and curtailing suburban sprawl's devastating impacts, are still elusive.

## **A Bay of Significance**

Protecting and restoring the Chesapeake Bay is a massive undertaking. It is North America's largest estuary and the third largest in the world. The bay's watershed spans 64,000-square miles (166,000-square kilometers) across six states and the District of Columbia. The headwaters fill Lake Otsego at Cooperstown, New York. Flowing downhill, the waters meet the Atlantic in southeastern Virginia.

The Chesapeake Bay is actually the valley of the lower Susquehanna River, an estuary drowned by the Atlantic as sea level rose over the past 15,000 years. The result is a shallow, tidal settling basin with an average depth of 21 feet (6.5 meters).

The Susquehanna/Chesapeake system is about four times larger than the next largest Atlantic Coast river system, the Connecticut. Its largest tributaries, the Potomac and the James, are major rivers in their own right. All told, 19 rivers and 400 smaller tributaries feed the Chesapeake. This sprawling complex of tidal rivers provides a major source of seafood, transportation, and recreational opportunities. The main stem runs 180 miles (290 kilometers) from the mouth of the Susquehanna to Cape Charles and Cape Henry in Virginia, including more than 4,600 miles of shoreline. More than 15 million people live within the bay watershed. One can get to a stream, creek, river, or stretch of bay shore in 10 minutes from virtually any spot in the watershed.

The Chesapeake Bay is a system of remarkable biological productivity. It supports more than 2,400 species of plants and animals, including 200 species of fish. Chesapeake waters and wetlands are important stopovers for many species of migratory birds.

The bay has long been important to its human population. A 1989 report by the Maryland Department of Economic and Employment Development put a \$678 billion price tag (in 1987 dollars) on the economic importance of the bay to the economies of Maryland and Virginia. It has long been a focal point of both regional and national culture, from the first permanent English settle-

ment at Jamestown to the surrender of General Cornwallis at Yorktown and the penning of the “Star Spangled Banner” by Francis Scott Key in Baltimore’s Harbor. Since 1800, the nation’s capitol has been in the Chesapeake watershed.

#### **Four Centuries of Decline**

The features that make the bay and its watershed such a rich ecosystem have attracted a burgeoning human population. In 1635, the watershed’s European population is estimated to have been 5,300. By 1700, it reached 88,000. Between 1900 and 2000, it rose from 6 million to over 15 million. By 2020, nearly 18 million people are expected to live in the region.

Today’s population adds more pollutants than ever before, even as we reduce the bay’s capacity to deal with pollutants through degradation of natural treatment systems like wetlands, underwater grass beds, forested buffers along streambanks, and oyster reefs.

Gauging the health of a complex system like the Chesapeake means bringing together a number of key indicators. In 1998, the Chesapeake Bay Foundation developed an index based on the best available historical and current information for twelve factors grouped into three categories:

- pollution—toxics, nutrients, dissolved oxygen, water clarity;
- habitat—wetlands, forest buffers, resource lands, underwater grasses;
- fisheries—blue crabs, striped bass, American shad, oysters.

The index measures today’s bay against the healthiest Chesapeake we know, the one that Captain John Smith described in his exploration narratives of the early

1600s. Modern science confirms many of Smith’s observations and sets the bay’s benchmark at 100, compared with a 28 in the Chesapeake Bay Foundation’s *2000 State of the Bay Report*. While that score marks a modest increase from an estimated 23 in 1983, it also represents a plateau over the past three years.

#### **Pollution**

During the past 400 years, the quality of bay waters has declined significantly. For 350 of those years, people saw the water not only as a provider of food, but also a vast waste receptacle. The most obvious problem was human sewage. During the 1800s, growing cities like Baltimore, Norfolk, Richmond, and Washington, D.C., built central waste collection systems and installed rudimentary treatment plants. The systems greatly reduced the threat of diseases like cholera, but the discharge pipes from the plants poured nearly raw sewage into those cities’ rivers.

The nitrogen and phosphorus from these discharges fertilized blooms of algae that clouded the waters, killed underwater grasses, damaged fisheries, and drove away vacationers and recreationists. As the algae cells died and sank to the bottom, they caused explosive blooms of decay bacteria that sucked dissolved oxygen out of the water, stressing fish and shellfish. The problem repeated itself in smaller cities and towns all over the bay.

Meanwhile, the Industrial Revolution was gaining momentum, adding fossil fuels to steam and water power. Manufacturing plants poured wastewater into the rivers, contributing even more

damage. By the mid-20th century, the Elizabeth, James, Patapsco, and Potomac Rivers were downright nasty waterways, serving as beasts of burden for their cities.

Gradually though, people began to realize that doing business didn't have to preclude healthy waterways. Major changes came with the passage of the Clean Water Act in 1972. Wastewater treatment became mandatory under the National Pollution Discharge Elimination System, in which the U.S. Environmental Protection Agency delegated authority to the states to regulate sewage and industrial wastewater discharges. The Potomac showed the most dramatic turnaround, as Washington's massive Blue Plains sewage treatment plant changed from the river's worst foe to its best friend. The Hampton Roads Sanitation District made important improvements as well. Gradually, the rivers returned to the point where they now have some healthy fisheries, though human population pressures still take their toll.

### **Contaminated Runoff**

The flow from industrial plant discharges was obvious. What we didn't realize for many years was how much damage stormwater runoff does to the Chesapeake. Three and a half centuries of clearing land for agriculture and timber throughout the Chesapeake watershed, with little attention to soil conservation, had already led to the silting-in of large harbors like Joppa on the Gunpowder River north of Baltimore and Dumfries on the Potomac, as well as countless steamboat wharves and creeks. From Princess Anne on the Eastern Shore of Maryland's Manokin River to Hillsboro on

Virginia's Mattaponi River, marshes grew up in what had been the big boats' turning basins.

As rainwater runs off land, it dissolves much of the material it encounters and carries even more in suspension. The faster it moves, the more material it carries.

Running off clear-cut timberland and farm fields, with furrows plowed straight uphill, rainwater in the past carried massive amounts of topsoil, which smothered oysters and clouded out light needed by underwater grasses.

In growing urban areas, sediment poured off bare construction sites. As motor vehicles replaced horses, rainwater on pavement picked up toxics like crankcase oil and antifreeze. Where wetlands and forests once trapped and partially filtered rainwater then slowly released it into tributaries and underwater aquifers, now concrete storm drains accelerated runoff, turning waters to which they flowed into collecting basins. Washington's still-dirty Anacostia River, which once had some of the finest wild rice marshes and herring runs on the Chesapeake, is a testimony to how much damage urban stormwater can do.

As the 20th century wore on, runoff problems that no one foresaw began to surface. The exhaust pipes of motor vehicles and power plant stacks gave off oxides of nitrogen that fell to the ground. Rainwater dissolved them and swept them overboard, adding to already heavy loads of nitrates. In areas of heavy commuter traffic, such as the Washington, D.C., and Hampton Roads metropolitan areas, these oxides of nitrogen became major contributors to the overfertilization of bay waters.

Meanwhile, as agriculture became

more intensive, more silt and nutrients flowed from the fields plowed close to the edges. Concentrated animal husbandry wastes, especially of poultry on the lower Eastern Shore and in the Shenandoah Valley, and of cattle in central Pennsylvania's Lancaster County, led to concentrations of nitrogen and phosphorus in areas where manure was spread repeatedly on land as fertilizer in concentrations higher than what crops could take up.

### **Habitat**

Reducing the pollutants flowing to the bay, of course, won't solve all the problems. Of equal importance is restoring the natural systems that filter those pollutants—forest buffers, resource lands, wetlands, and underwater grasses. Trees slow the fall of rain to the ground, and the thick, spongy soil of mature woodlands soaks up the water, releasing it slowly to adjacent streams. The trees' root systems take up nutrients for growth and hold soil around them. The Chesapeake Bay watershed evolved during the past 20,000 years with virgin forests that filtered most of the rain that fell. During the past 400 years, as we have cleared land, cut timber, and covered soils with pavement and rooftops, we have radically altered the way water runs off these lands.

The past century, however, has seen improvements in forest cover. Lands that were stripped of their trees in the 19th century have grown back, often with the help of timber companies. The bay watershed today is about 60-percent forested, an increase of 10 percent since 1830. Today, however, the watershed's timber stands are under pressure again, mostly from

development. Clearing mature trees to build houses and replacing them with young trees does not solve the problem. In addition, sprawling development fragments forests, and clearing land along waterways reduces their capacity to treat runoff.

The Chesapeake watershed has lost 43 percent of another of its great natural filters since 1600—wetlands. It's easy to understand why some of these losses occurred. With mounting loads of sewage and polluted runoff, some wetlands held legitimate threats of diseases, like cholera and malaria, until development of modern medicines. Farmers drained low, wet spots in fields to convert them to arable land, often with the encouragement of government agencies. Developers filled tidal wetlands to build land for houses.

Most of this destruction was based in ignorance. We didn't understand the roles that wetlands played in the Chesapeake system, providing habitat for wildlife, nurseries for fish and crabs, and water treatment systems that we now refer to as the "kidneys of the bay." Destruction of tidal wetlands has been much arrested since passage of protective laws in Maryland in 1970 and Virginia in 1972. Even so, losses of nontidal wetland have continued even to this day.

Similar declines have plagued underwater grasses. The bay's 16 or so species of these plants provide essential habitat for fish and shellfish, especially our beloved blue crab. They trap suspended sediment and turn nutrients into building blocks for growth. These grasses require clear water to grow and flower, however.

We don't have hard data, but extensive anecdotal evidence indi-

cates that the Chesapeake held about 600,000 acres (240,000 hectares) of underwater grass in Captain John Smith's time, growing out to depths of 12 to 15 feet. Maps from 1916 on the upper tidal Potomac indicate vast coverage, as do aerial photographs of Tangier Sound in the 1950s.

Algae blooms from sewage and sediment pollution from development reduced water clarity on the Potomac during most of the century. The grasses crashed. The story is much the same throughout the system. By 1984, coverage of the bay's underwater grasses declined to about 37,000 acres, or a loss of about 94 percent. They rebounded to about 70,000 acres in 1993, with greatest gains in the tidal Potomac, as a result of good sewage treatment. Since then, however, the trend has flattened.

### **Oysters**

The greatest decline of the 20th century and, paradoxically, the strongest potential for restoration, lies with the Chesapeake's oysters. Before 1870, the bay's oysters grew in reefs so high that they were hazards to navigation. They were so abundant that they removed 25 to 40 percent of algae blooms in warm weather.

But then we began harvesting them faster than they could reproduce. Between 1890 and 1905, baywide harvests dropped from 15 million to 5 million bushels per year as dredgers scraped the reefs flat. Despite the declining harvests, oysters were still abundant enough that most people scoffed at the notion that they were being overharvested.

Overharvesting was not the only problem, however. The oysters growing on the bottom were in-

creasingly hampered by poor water quality. They had to expend more energy pumping sediment out of their gills. And, too, the concentrations of food—phytoplankton, which need sunlight for photosynthesis—and dissolved oxygen are lower at depth. Oyster growth and reproduction slowed. During the next 50 years, oyster harvests trailed off to a couple of million bushels a year.

In the 1960s, the disease MSX struck the high-salinity beds of the lower bay, decimating much of Virginia's public oyster grounds. In the drought years of the 1970s and 1980s, the disease worked its way into Maryland as well. In the 1980s and 1990s, another disease, Dermo, also began to affect the stocks. The baywide harvest declined to fewer than 100,000 bushels in 1993, the final step in a 99-percent drop over 100 years.

The decline was devastating to the communities of watermen who depend on oysters for income to carry families through the winters. In addition, the loss removed the most effective natural water treatment system even as the region's growing human population added more sediments and algae-growing nutrients to the system.

The early 1990s were a time of great pessimism about the future of the Chesapeake's oysters, but the seeds of recovery were sown even then. People began to recognize the vital ecological roles that oysters play in the bay, providing live-bottom habitat for fish and other shellfish, filtering sediment, and converting sunlight-blocking algae into tasty meat.

An oyster research and hatchery program at the Virginia Institute of Marine Science developed a technique for growing oysters in

floats, which led to an explosion of oyster gardening by private citizens. In the floats, the oysters grew fat and fast, reaching a harvestable size of 3 inches (8 centimeters) in 16 to 18 months instead of the three years that it takes in the wild. These fast-growing commercial oysters can easily outrun MSX and Dermo, which require 24 to 36 months to kill their hosts. Clearly, the Chesapeake can still grow top-quality oysters.

Also in the early 1990s, Jim Wesson, shellfish repletion officer at the Virginia Marine Resources Commission and a former waterman, began experimenting with high reefs built of shell and seeded with large oysters. These reefs mimicked the shape of those seen in the prints of the bay from the 17th century, the way oysters grew naturally before we began harvesting them intensively. To date, he has built 20 reefs in Virginia waters, with at least 10 more planned for the next two years. Planted with large oysters as broodstock, the reefs show greatly increased reproduction, which is spreading to nearby bottoms planted with shell.

Increasingly, broodstock oysters grown from disease-resistant strains—developed at the Virginia Institute of Marine Science and the University of Maryland’s hatchery on the Eastern Shore—are being raised by students and private citizen gardeners who want to help in the effort. The Chesapeake Bay Foundation is taking the lead in organizing citizen growers in both states.

Some of the broodstock includes large wild oysters with disease resistance, harvested by watermen and bought for the reefs by the Virginia Marine Resources

Commission and the Chesapeake Bay Foundation.

### **Save the Bay**

These stories of pollution, habitat, and oysters tell not only of decline, but also of a subtle shift in attitudes toward the bay and its natural systems. By the 1960s, a few voices in the watershed started to call for change. In 1964, a group of Baltimore businessmen—all sailors, waterfowl hunters, and fishermen—had lunch with Rogers C.B. Morton, then a congressman from Maryland’s Eastern Shore. They wanted his help with problems they saw looming on the Chesapeake: more boats, more people, more houses, poor sewage treatment, dirty industrial discharges.

Morton responded by saying that they could not expect the government to fix all the bay’s problems. “There is a great need,” he said, “for a private-sector organization to represent the best interests of the Chesapeake Bay. It should build public concern, then encourage government and private citizens to deal with these problems together.”

The words struck home. By 1967, the group, led by the late Arthur Sherwood, had formed and chartered the Chesapeake Bay Foundation to be that private-sector voice working on behalf of the bay. They recruited a board of trustees representing a variety of interests from throughout the Chesapeake watershed. To get out their message, they adopted *SAVE THE BAY* as the Chesapeake Bay Foundation’s motto and printed the first run of the distinctive blue-and-white bumper stickers that are now so common throughout the watershed.

The Chesapeake Bay Foundation’s

beginnings were modest. Early in 1970, with membership at 2,000 and a staff of three, Arthur Sherwood took over as executive director and settled on two programs—environmental education and resource protection—with land conservation an integral part of the protection effort.

For the next 30 years, the Chesapeake Bay Foundation would represent the growing ranks of watershed citizens who demanded improvements in the bay’s health. The Chesapeake Bay Foundation served as a vocal advocate in Annapolis, Harrisburg, Richmond, and Washington, D.C., while working with citizen volunteers to begin massive restoration and protection programs on the ground. At the same time, the organization taught growing numbers of students and adults about the bay and its watershed through on-the-water experience.

By the end of the century, the Chesapeake Bay Foundation would become the nation’s largest regional environmental organization, with the largest field-based, on-the-water, environmental education program in the world.

The organization’s success lies not only in its passion for its mission, but also in its ability to reach across divides of party politics, state lines, and socioeconomic status to tap into the public’s tremendous love for the Chesapeake.

### **Shared Vision**

In the early 1970s, bay protection and restoration on both federal and state levels started to take off. Maryland and Virginia had just enacted their tidal wetland protection acts. Within a couple of years, tidal wetland loss fell by more than 90 percent.

By 1976, the Chesapeake Bay

Foundation had sufficiently raised public concern about the future of the bay that Senator Charles "Mac" Mathias, Maryland Republican and a member of the Chesapeake Bay Foundation's board of trustees, pushed through Congress a seven-year EPA-sponsored Chesapeake Bay study. The study provided much of the scientific basis for the broad interstate effort that continues today.

In 1983, EPA issued its report, documenting systemic declines around the Chesapeake. The report focused, not on a single cause for the decline, but on the accumulation of insults that the bay was suffering as the result of human pressures.

William C. Baker, who had become president of the Chesapeake Bay Foundation in 1981, seized on the results of the bay study and, using all of the foundation's resources, entered vigorously into the planning processes then underway in Maryland and Virginia for programs to restore the bay.

In late 1983, the governors of Maryland, Virginia, and Pennsylvania and the mayor of the District of Columbia met at a major conference, along with staff from the Chesapeake Bay Foundation, other environmental organizations, and research laboratories. Their task was to hammer out what would become the first interstate Chesapeake Bay Agreement. A particularly important outgrowth of this agreement was Maryland's Critical Area Act, the first land-use legislation intended to minimize the effects of shoreline development on the bay ecosystem. Virginia added the Chesapeake Bay Preservation Act, the commonwealth's own land-use law. In Pennsylvania, the focus was on agricultural issues in

the intensely farmed south-central counties along the Susquehanna River. Additional attention has been directed to wastewater treatment, urban stormwater runoff, and wetland protection. Meanwhile, the outpouring of public interest in cleaning up the Chesapeake grew tremendously.

In 1987, Virginia's Governor Gerald L. Baliles intensified the cleanup effort with a new Chesapeake Bay Agreement that called for a 40-percent reduction in the flow of the nutrients nitrogen and phosphorus into the bay, along with the specific goal of elimination of toxics from all controllable sources.

In 1991, to celebrate its 25th anniversary, the foundation commissioned the writing of the book *Turning the Tide: Saving the Chesapeake Bay* as its first *State of the Bay* report. Tom Horton, the book's principal author, concluded that the bay was dangerously out of balance and in need of a three-pronged approach to restoration: reduce pollution, protect and restore habitat, and replenish fisheries.

In 1993, the Chesapeake Bay Foundation began a long-term planning process designed to refocus its goals and to restructure itself for the 21st century. The planning resulted in development of the indicator benchmarks used in today's annual *State of the Bay* reports.

In 1997, a new threat arose from the fish-killing microorganism *Pfiesteria piscicida*. *Pfiesteria* had been associated with large fish kills in North Carolina's Pamlico Sound, whose waters were highly enriched by runoff of waste were from hog farms. The outbreaks in the bay began that summer on the

Pocomoke River, which has tens of millions of chickens in its watershed. In late summer, kills also occurred on Kings Creek, a tributary of the Manokin River, and on the Chicamacomico River, both farther up Tangier Sound on the Eastern Shore. The kills were significant, both in loss of fish and in human illness suffered by watermen and state workers investigating the kills. Monitoring efforts by field staff in Virginia found *Pfiesteria* to be active there too, but at a much lower level.

Maryland Governor Parris N. Glendening responded by instituting a blue-ribbon commission to come up with recommendations for state spending and legislation to deal with the problem. *Pfiesteria* is a compelling reminder that the Chesapeake is not yet saved, that the cleanup is very much a work in progress. In both Maryland and Virginia, it has galvanized intensive efforts to strengthen nutrient reduction programs.

#### **At the Crossroads**

*Chesapeake 2000*, the third Chesapeake Bay Agreement, now raises the bar for bay restoration. Despite progress on many fronts, fundamental challenges to the Chesapeake's health remain. The central problem is that the bay watershed is growing fast, as anyone who drives our roadways knows all too well. Maintaining the status quo in bay restoration means losing ground.

The 1987 Chesapeake Bay Agreement mandated not only a 40-percent reduction of nitrogen and phosphorus, but also a permanent cap thereafter. We've missed the 40-percent goal, and current evidence suggests that restoring the system will require a

50-percent reduction. The most difficult challenge, however, may be maintaining the cap in the face of population growth. One of the watershed's sewage treatment plants, for example, is considering a 50-percent expansion to accommodate new houses and offices, while maintaining the same rate of nitrogen removal. That means a 50-percent increase in its effluent's nitrogen, which runs counter to everything we're striving for.

Even more worrisome is the way population growth currently gobbles up open land throughout the watershed at a rate of 10 acres every hour. In graphic terms, this means the watershed is losing an area of open land the size of Washington, D.C., every 10 weeks. Thus *Chesapeake 2000* includes a provision to reduce the rate of land conversion for harmful sprawl by 30 percent and to permanently preserve 20 percent of the land area of the watershed. The agree-

ment includes a number of incentive-based tools like cost-share programs, easement purchases, and tax credits to achieve the 30-percent reduction.

This is the most specific Chesapeake Bay Agreement by far. Chesapeake Bay Commission's Ann Swanson notes that the agreement includes 97 explicit and interlocking commitments within five categories: living resource protection and restoration, vital habitat protection and restoration, water quality restoration and protection, sound land use, and stewardship and community engagement.

#### **Back to the Future**

After our conversation at the Noonan Center, we board a canoe fleet to explore underwater grass beds in nearby Hopkins Cove. In 1997, the cove's bottom was barren. A year later, it was half-covered with widgeon grass. Last year, it held a thick carpet. This year, it

has a lot of bare spots again. Maybe the light-blocking effects of the mahogany tide algae bloom following last spring's rains thinned out the grass. Maybe the several dozen mute swans that live in the area overgrazed the beds during the summer—we shoo away 18 of the big birds as we approach. Maybe both factors are at work.

Earlier, Swanson had said she was both proud and troubled as she contemplated the Chesapeake's future. She was right on. We've made important progress, but much work remains. *Chesapeake 2000* gives us a strong, specific action plan. Now, we must get on with it. ■

*Geoff Oxnam is media relations manager and John Page Williams is senior naturalist for the Chesapeake Bay Foundation, in Annapolis, Maryland.*



# A River Runs through It

*An integrated system of dams gives TVA the unique ability to manage the Tennessee River's potential for a broad range of benefits.*

**BY JACK DAVIS, RENEE HURST, MORGAN GORANFLO JR.,  
AND ARLAND WHITLOCK**

**E**lectricity has fueled past prosperity; the lifeblood of the future is water. Human imagination will usher forth new technologies and the promise of renewable and distributed energy generation. But water is a finite resource with a finite carrying capacity.

Historically, the Tennessee Valley has enjoyed ample water supplies—the result of precipitation from Gulf moisture pushed eastward by large frontal movements. Average annual rainfall in the region is 51 inches (130 centimeters), compared to 5 to 20 inches in the southwestern United States, about 30 inches along the northern tier states, and 40 to 45 inches in the northeast.

Even the Tennessee Valley, how-

ever, is not immune to water shortages. An extended drought from 1984 through 1988 caused municipalities to restrict water use and accept a higher rate of pollution due to the reduced assimilative capacity of the river. More recently, from 1998 through today, lower than normal rainfall has caused drought conditions across the region. For calendar year 2000, precipitation averaged 38 inches across the Valley—13 inches below normal—demonstrating again the region's dependence on large volumes of water for home use, not to mention navigation, power generation, recreation, and industrial needs.

## **Growing Demand**

Consider how the region is growing, and the seriousness of the

situation is readily apparent. About 4 million people get their drinking water from the Tennessee River and its tributaries. Likewise, numerous water-intense industries rely on steady, large-volume withdrawals. This includes TVA, which withdraws about seven billion gallons a day for thermoelectric power generation—primarily for cooling water used in the process of generating fossil and nuclear power. TVA's ability to operate its dams to meet water demands for power generation is a little-understood part of what makes the TVA system fully integrated and operationally interdependent. All this adds up to a total daily withdrawal of more than 9 billion gallons (34 billion liters) a day. Fortunately, most of this water is returned to the river where it is available for use over and over again.

Rapid growth in the amount of water used by industry is realistic given the region's advantages: its location near the population center of the United States, interstate highways crossing from east to west and north to south, an excellent rail network, major regional airlines, barge transportation, four distinct seasons and relatively mild winters, and, perhaps most important, a reliable water supply of good quality.

Water usage issues become even more alarming from a broader geographic perspective. Concerns over water supply have already hit Atlanta with a vengeance. (See "Thirst for Growth" in this issue of FORUM.) But the problems with ensuring Atlanta's water supply do not end with Atlanta. Medium-size and smaller cities, and even towns all over the country, already are struggling with tre-

mendous growth in water usage.

A fight brewing in north Georgia is symptomatic of what the region will likely be facing in the not too distant future. According to a lawsuit recently filed by the Southeastern Federal Power Customers Inc., the U.S. Army Corps of Engineers permitted a small amount of water to be removed from Lake Lanier in the 1970s under contracts with the Atlanta Regional Commission, Gwinnett County, and the cities of Cumming and Gainesville. The removal of water greatly increased over the years from about 10,000 acre-feet (12 million cubic meters) per day in 1977 to about 134,000 acre-feet per day in 1999—an increase of almost 1,200 percent. Few water sources can long support that rate of growth.

### **Escalating Conflict**

Growth—in terms both of population and water use—is clearly the most serious issue facing water management in the next century. Our demands for ample drinking water, wastewater treatment, and industrial water supplies will bring conflict. Upstream and downstream users already are vying for increased benefits from a fixed resource. Water quality, fisheries, recreation, assimilative capacity, and other in-stream uses have taken on new value.

The entire northwest Georgia area above Atlanta is growing rapidly and exceeding the capacity of existing groundwater and surface water supplies. Similar problems are developing in the areas around Birmingham and Cullman, Alabama, and in portions of Alcorn, Tishomingo, Prentiss, Itawamba, and Lee Counties in northeast Mississippi. Each of these areas may

look to the Tennessee River for additional water to supplement or replace declining groundwater supply sources or inadequate surface water resources. Not surprisingly, the state of Tennessee recently enacted legislation to require state permits for all water transfers inside and outside its boundaries. (See “Treading Political Water” in this issue of FORUM.) More such action can be anticipated as different political units realize the potential for loss of control over their water supply.

Circumstances similar to those at Lake Lanier will become more widespread. Greater pressure can be expected on TVA’s tributary reservoirs for municipal water supply as the relatively small cities in these areas grow. The number of regional water systems is steadily increasing, allowing distant users to access water directly from these reservoirs, without investing in lines to return used water to source streams.

Water transfers for drinking water purposes already are taking place. For example, last year, 35 transfers took place among public water systems in Tennessee as municipal water distribution systems cross watershed boundaries to deliver safe drinking water to residential and commercial customers whose private wells failed or became contaminated.

During long-term droughts, these withdrawals will lower pool levels, reducing the amount of water available for hydropower generation, thermal cooling, navigation, assimilative capacity, recreation, and other downstream uses. They also will set the stage for conflicts over water use and supply—conflicts entwined with economic development and envi-

ronmental protection and therefore all the more difficult to resolve.

While these conflicts can’t be avoided, they can be minimized. The first requirement is to apply an integrated approach to river management, making every drop of available water count repeatedly as it passes downstream. A second requirement is to have an unusual degree of operating flexibility, taking full advantage of the water nature provides. The third is to take advantage of regional governance to allocate available water wisely, providing a predictable and reliable balance among competing demands. The TVA model meets all these requirements.

### **An Integrated Approach**

There are literally thousands of dams in the United States, but virtually none are operated like TVA dams. Most reservoir projects were built for specific purposes—irrigation, hydropower production, water supply diversion, or navigation—and for the benefit of specific political jurisdictions. In contrast, TVA’s 49 dams were built to provide the total benefit of the Tennessee River to the people of a seven-state region by balancing the use of the water for multiple purposes. No single activity was to be considered an end in itself. Instead, the focus was on realizing the full potential of the river.

Two primary types of dams and reservoirs were included in the design of the integrated system. The topography of the mountainous eastern Valley area was conducive for TVA to build at least one high, multipurpose dam on each of the major tributary rivers. These dams created reservoirs to provide seasonal flow regulation,

by using a wide range of pool level variations throughout the year to store and release water as needed, fluctuating on average about 30 to 40 feet (10 to 13 meters) per year.

On the Tennessee River itself, with its wider floodplain and pre-existing urban developments nearby, TVA built a series of dams and reservoirs to ensure a navigable pool from Paducah, Kentucky, to Knoxville, Tennessee. These reservoirs in general do not have as much storage space for flow regulation as their tributary counterparts. Their pool levels typically fluctuate only 3 to 6 feet on an annual basis.

When TVA was created in the 1930s, the river system was operated primarily for navigation and flood control and, to the extent consistent with these purposes, for power production. Today, recreation, water quality, water supply, and other benefits also are factored into the system's operation. This expanding list of uses demonstrates the breadth of benefits that can be provided through an integrated approach, and it shows how the TVA model can uniquely adapt to changing needs and user expectations.

TVA is able to provide such a wide range of benefits and to respond to evolving social values and economic demands by operating its 49 dams as a single unit. The reservoirs and dams work together to make sure the right amount of water is available at the right place at the right time—and even at the right temperature.

A drop of water that falls as rain in the mountains of western North Carolina is used over and over as it makes the long journey to the mouth of the Tennessee River near Paducah, Kentucky—a distance of

well over 800 miles (1,300 kilometers). That same drop of water is used as habitat for fish and flotation for navigation, as coolant for power plants and propellant for spinning turbines, as liquid for human consumption and carrier for industrial waste.

The wisdom of this multipurpose approach is well established. TVA's integrated water-control system transformed the Tennessee River and its tributaries into one of the most useful river systems in the world. It tamed the Tennessee's unpredictable flow, which once varied seasonally at Muscle Shoals, Alabama, a hundredfold, from little more than a trickle of about 4,600 cubic feet per second (130 cubic meters per second) to a torrent of over 460,000 cubic feet per second. It has prevented more than \$4.8 billion in flood damages in the Tennessee Valley since 1936, plus more than \$348 million in damages on the lower Ohio and Mississippi Rivers.

It has opened a 650-mile navigable channel that links the Tennessee Valley ports, by way of an inland waterway system, with ocean ports leading to countries around the world. And, of course, the system helped generate electric power for industrialization, rural electrification, and the development of the region. Today, TVA also manages the river system to maintain reservoir levels for recreation, provide a reliable water supply, and protect aquatic habitat, particularly downstream of its hydropower dams.

### **Operating Flexibility**

Operating the TVA system as a single unit is not the only factor that allows TVA to provide such a wide range of benefits, however.

These benefits also arise because of a key difference in the way TVA operates its dams compared with other operators. Most federal dam operators choose to be very conservative, accepting a smaller accrual of total benefits by reducing the need for the system to respond quickly to changing conditions. By contrast, TVA takes a much more aggressive approach, placing considerable responsibility on its water managers to respond to changes continuously to optimize benefits each day while protecting downstream areas, ensuring adequate reservoir levels for recreation and maintaining the integrity of the system.

**Seasonal use of storage.** Most federal and private reservoir projects have specific allocations for individual purposes, such as power, flood control, and water supply. Those dams used for flood control typically have been designed and constructed following one of two approaches: either a reservoir is kept empty for flood control at all times, or a designated volume—a definite layer—is reserved in the top portion of the reservoir for flood control. Other uses are not permitted to encroach on this designated volume at any time.

TVA's system, on the other hand, is built around the idea of allowing seasonal variations in the use of storage space. The same space, or designated volume, may be used for both flood reduction and other purposes at different times of the year. An optimal zone of operation has been developed for each TVA reservoir, based on many decades of experience charting demands for both water use and flood storage space throughout the year. This zone is defined by an upper boundary, called a

flood guide, and a lower boundary, called a minimum operating guide. The flood guide level is set primarily to reserve storage space for runoff from the heavy rains that typically fall in winter, but it also gives TVA the flexibility to generate low-cost electricity during wintery days. The minimum operating guide represents the storage space conserved for providing downstream minimum flows. If the reservoir level drops below this guide, water is released only to maintain minimum flows for aquatic life, water supply, navigation, and the safe operation of thermal power facilities.

**Swift response to rainfall.** TVA typically reserves less storage space in its reservoirs than do other federal dam owners. Most federal reservoirs have a large flood control reservation above maximum pool level—4 or 5 inches or more. Some western reservoirs can actually store more water than enters the reservoir during an entire year. In contrast, most TVA tributary storage reservoirs have only an inch of storage space at summer pool levels. Several TVA reservoirs along the main Tennessee River have a summer level that is only a few tenths of a foot below the top of the dam's gates.

While the additional storage space allows water managers elsewhere in the nation hours or even days to refine forecasts before deciding on a release rate from their dams, TVA water managers must react to storms much more quickly.

A second challenge is presented by the lack of information about the timing or volume of runoff that will be received in the future. In other locations where snowmelt is the primary source of runoff, precise measurements can be made of

the depth and density of the snowpack. This gives water managers advance notice of the volume of runoff likely to occur during the spring thaw and weeks, or even months, to prepare. In contrast, most reservoir scheduling for flood control in the TVA region must be done in reaction to rainfall as it is occurring or has just occurred.

To meet these challenges, TVA's River Forecast Center is staffed around the clock, 365 days a year. Preparation, planning, and practice are watchwords, and a premium is placed on retaining experienced staff. Water managers are trained not only in flood control operations, but in all benefit areas. They are aided by rainfall reports from nearly 300 raingages and 60 streamgages strategically located throughout the Tennessee Valley, supplemented by state-of-the-art radar technology.

**Engineering discretion.** TVA delegates extensive responsibility to its water managers to make their best decisions, based on up-to-the-minute assessments of current and expected conditions and needs. This concept allows the accrual of benefits that would not be possible under any other scheme of operation. The majority of river and reservoir systems in the United States are scheduled in strict adherence to a prescribed set of rules and water-use allocations often approved at the national level. TVA water managers continually evaluate current and expected conditions at the local level, employing a systemwide perspective to ensure the best use of the water for all prescribed beneficiaries.

**Scheduling frequency.** Frequent reevaluation of conditions leads to frequent rescheduling of releases from TVA reservoirs. The storage

capacity of TVA reservoirs is a critical factor. Because there is so little storage in main-river reservoirs, gate changes are often necessary with little warning.

In response to a large rainfall in 1990, for example, discharges from TVA's Wheeler Dam increased from zero at 1 a.m. to more than 300,000 cubic feet per second at midnight to regulate downstream flood stages.

Run-of-the-river reservoirs—reservoirs that have to pass on all incoming flow because of limited storage space—require more immediate decisions in response to significant changes in inflows. At run-of-the-river projects like Ocoee No. 2 Dam, for example, coordinating releases for both power and whitewater recreation requires particularly close scheduling.

The uses that TVA reservoirs serve also affect scheduling. Multipurpose dams along the main Tennessee River and tributary dams at summer pool levels must be scheduled and rescheduled frequently during rainy weather to ensure proper use of the limited flood storage space. In addition, most main-river TVA dams require frequent scheduling because power needs fluctuate greatly during the day, and the economic value of hydrogeneration changes on an hourly basis.

While these changes can be anticipated to some degree, changes in weather or other power supply costs can dramatically affect the way releases are scheduled to achieve maximum benefits. Other uses, such as recreation and thermal cooling of power plants, also require frequent adjustments in schedules to optimize water use. Meeting a downstream water re-

quirement might require changes in flow at several upstream dams over a considerable period.

### **Regional Governance**

Every major American watershed is managed under increasingly competitive pressures for reallocations of water, and in virtually all cases, individual watershed interests and jurisdictions are trying to protect their traditional water allocations. Such a situation is certainly understandable in the absence of any coordinated effort. But rainfall and flowing streams do not recognize political and geographic boundaries, and any solution for fair public use of the water resource should address all concerned interests. Upstream and downstream interests—which increasingly face new pressures brought on by water shortages outside the drainage area—need to be coordinated.

Again, the TVA model is instructive. Prior to the creation of TVA, two schools of thought existed regarding the management of natural resources. One school argued that such vital resources could be managed effectively only by a highly centralized national government. The other school of thought argued that natural resources should be managed by individual states.

TVA demonstrated that yet a third system, a regional agency, could effectively manage large river and land systems, especially if the agency, as President Franklin Roosevelt characterized it, is “clothed with the power of government but possessed of the flexibility and initiative of a private enterprise.”

TVA was headquartered not in Washington, but near the river it

was to manage; and its resource management responsibilities were not constrained by political boundaries, but instead were drawn around a single ecosystem, including parts of seven states and crossing city, county, and state boundaries.

Contrast the Tennessee Valley with the Pacific Northwest, where 17 authorities and two countries make decisions about managing the Columbia River, and the advantages of a single source of regional jurisdiction are obvious. Regional governance enables TVA to efficiently and fairly distribute the benefits of the river and its tributaries, while assuring local communities of control and influence over their water resources. It also enables TVA to provide a reliable and predictable river resource that fortifies local economies and unifies the region across state and local boundaries.

### **The Future**

The TVA river system is unique in its design and operation. Nowhere else in the world are dams, reservoirs, navigation channels, and electric systems operated as a single unit. Nowhere else do water managers have the operating flexibility to make the most efficient use of resources based on an up-to-the-minute assessment of current and expected conditions and needs. Although controversy continues regarding the issue of national oversight and decision making, most would agree that this experiment in watershed stewardship has been an unparalleled success in delivering its prescribed benefits to the Tennessee Valley region.

TVA’s authorized mission is ongoing. The economic develop-

ment in the Tennessee Valley is sustainable in large part because TVA’s integrated system supplies reliable water and electricity without depleting the resource. The demands for other uses of the river—for navigation, flood control, recreation, fishing, aquatic habitat, waste removal, thermal cooling, and other in-stream uses—will continue to increase. The job of balancing these competing needs will fall to TVA, and the Valley’s long-term economic prosperity will hinge largely on the balance achieved.

In 1999, TVA created a citizen advisory council to help with this delicate balance of public benefits. The Regional Resource Stewardship Council is advising TVA on policies, practices, and priorities in deciding how best to use the Valley’s water and other resources for the benefit of the public. Its 20 members represent distributors of TVA power, industrial customers that buy electricity directly from TVA, beneficiaries of navigation and flood-control activities, and recreational and environmental interest groups. This council will play an important role in anticipating and meeting the future water challenges facing the Tennessee Valley.

Ironically, the greatest of these challenges may be the growing threat to the integrated nature of the TVA system—the unique characteristic that has made the nation’s investment in TVA’s dams so productive. Several scenarios—most put forth by private utilities in the Northeast and Midwest—have been discussed in recent years, including operating TVA under different authority, splitting its responsibilities with another federal agency, or even privati-

zation. Under any of these scenarios, TVA's integrated system would likely disintegrate.

Disintegration would preclude the most efficient use of the river, resulting in an immediate waste of water and money and a decline in the level of benefits the citizens of

the Tennessee Valley have come to expect from the Tennessee River. Worse, the nation would lose a valuable model for dealing with its future challenges. The future of the Tennessee Valley Authority bears watching closely. Much is at stake.■

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# INSIGHTS

## Overcoming the Myths of the North

*To help developing countries improve water quality and sanitation, scientists and engineers need to learn the arts of persuasion and cooperation.*

BY CHRISTOPHER HAMLIN

A great many of the world's water problems are experienced and resolved on the most local levels. In the developing world, the large-scale turnkey projects of international agencies often don't work as well as the smaller "own-key" projects developed locally. Often, the large projects assume political, financial, professional, and administrative structures that are unavailable in developing countries.

In particular, such projects are usually ill-suited to the needs of the large numbers of poor people, often transients, who occupy temporary accommodations within and around the expanding metropolises of developing countries. Indeed, lack of adequate sanitation is a distinguishing feature of those populations.

Those who live in such communities do solve water and sanitation problems, but rarely in optimal ways. They rely on

wells, pumps, and local water sellers; dig latrines; and use other low-tech means. In many cases, public health workers, local and foreign, have helped make such locally appropriate technology solutions significantly more satisfactory.

In cases like this, field experience overcomes professional traditions and training, as well as existing institutions for the application of expertise. Some of the assumptions about problem solving, however, inhibit a more flexible response to the water and sanitation problems of cities in the developing world. Therefore, I propose a different perspective toward the application of expertise.

### **Problem Solving**

In retrospect, the progress in sanitation that occurred in towns in the late 19th and early 20th centuries in America and Europe can seem a mere matter of implementing straightforward technical solutions. In the

developed North, our ability to provide water and sewerage to periurban areas—we call them suburbs or housing developments—has generally kept pace with urban growth. For the most part, we have maintained and sometimes improved environmental standards.

Unavoidably, expectations for the developing world are informed by the sanitary achievements of the cities and towns of the industrialized countries and on beliefs, often incorrect, of how those achievements came about. As public health officials and sanitation workers became more professionalized, the difficulties were foreshortened and the successes magnified. Textbook traditions tend to extract soluble problems from complex social, political, and physical situations: thus, engineering education rarely involves immersion in local politics and rarely confronts the possibility that solutions that look good on the drawing board may be

politically uninteresting or otherwise unfeasible. Agencies, whether nongovernmental or public, typically treat hygienic infrastructure in terms of problem solving, assuming that a discrete and definable problem exists, and that a solution needs to be designed and implemented—ideally within a short time frame as dictated by a world driven by annual reports and funding deadlines.

To improve a community's water and wastes systems may seem a straightforward matter requiring only a minimally competent civil engineer. Isn't it just a simple matter of digging some holes, each allotted to its proper purpose? In fact, even with unimpeachable expertise, very modest improvements in public hygienic arrangements can be enormously difficult to achieve. Hygiene, after all, is not a subspecialty of medicine or engineering, but a facet of community life. Local views about which people and actions are clean or dirty, acceptable or outrageous, form key parts of the unwritten rules that govern social life.<sup>1</sup> In Gabriel Chevallier's comic novel *Clochemerle*, so minor a matter as the building of a new public urinal disrupts the stability of a French market town.<sup>2</sup> What seem to outsiders like straightforward solutions to clear-cut technical problems involve changes not only in daily life and habits, but in standards of public behavior, familial, gender, political, and economic relations, and even personal identity.

As an historian of science, technology, and public health, I draw on the historical record to reveal how much we misunderstand and oversimplify the

problems encountered in creating urban sanitary infrastructure. On the other hand, I also draw on history for general suggestions of how to successfully apply expertise to local water problems in the developing world.

The historical record suggests to me three main myths of the North, templates we have misdrawn from the experience of public health in the industrialized nations, and which continue to inform our intervention in the developing world. The first is that external authority—for example, education, access to expertise or finance, or coercive regulation—is a necessary, and even sufficient, basis for hygienic improvement. The second is that changes in hygiene come about through an orderly pattern of problem-definition, goal setting, analysis, implementation, and assessment. The third is that improved hygiene is mainly a matter of applying general scientific principles to particular cases. I do not suggest that states, experts, or nongovernmental organizations should not be involved in urban water policy. I am calling only for a fuller recognition of, and greater response to, some of the frequently encountered constraints in the establishment of effective measures of sanitation.

### **Safe Water as Social Action**

Revisiting one of the most famous cases of public health improvement will help make clear why those assumptions are inadequate. Consider John Snow's 1854 demonstration of cholera as a water-borne disease. As usually written, the story exemplifies successful applied science. By mapping cholera

cases in the epidemic of 1853-1854, the London physician associated cholera incidence with consumption of fecally contaminated water. On the basis of that evidence, Snow predicted that the causal agent of cholera was a particulate microscopic agent, predictions confirmed by Robert Koch three decades later. Once Snow's work was published—and publicized—the onus, and equally the basis, for action passed to governmental bodies. They invested in the new plant that would prevent fecal contamination, though they did so less rapidly than one might expect. This sounds like an exemplary story of external authority, applied science, and a bureaucratic mode of decision-making—until we look more closely at the processes of change.

To start with, Snow's discovery did not mark the beginning of concern about the effects of water on health—that goes far back in western and nonwestern medical traditions. In London, complaints about bad water were central in a campaign for better and cheaper water a quarter of a century before Snow. One might wonder how this could be; the complainers were not thinking of specific water-borne diseases, and they had no epidemiological data nor any satisfactory means of measuring water quality. By the time Snow wrote, sanitary reformers had already directed the public's imagination to environmental quality and, in particular, to contamination by wastes.

Still, even in his own city, Snow's science alone could not compel the kinds of changes we might expect. Contemporaries,

even those who did not take issue with Snow's analysis of the data, did not wholly agree with what Snow had shown. That cholera was transmitted by water in one case did not mean that this was the only, or the usual, means of its transmission. Some accepted that contaminated water had been implicated in the occurrence of the disease, without adopting the view that something in the water was a necessary cause. Some were not convinced that cholera was a specific disease, or, if it was, that a specific disease implied a specific cause. Some demanded that the supposed causal agent be identified and isolated, but even when Robert Koch later identified the cholera vibrio in the early 1880s, this seemed to many authorities not explanation enough, since not everyone who ingested the microbe got the disease.<sup>3</sup>

It was evident that there was some relationship between cholera and contaminated water that warranted further investigation, but that tentative generalization was inadequate to answer the most important question Snow, and those water analysts who accepted his demonstrations, could not answer: Will this water kill me? They could point, with greater or lesser precision, to an increase in the level of risk from ingesting contaminated water. Simply to say, "I don't know," or to refer to the general process of microbial transmission, or the increased likelihood of infection, was unsatisfactory in this particular case, and is not likely to be helpful in similar situations today.

Probabilistic statements in

particular are hard to assimilate, especially when they refer to events that may still seem unlikely.<sup>4</sup> Rarely can the sanitation professional guarantee that a particular action—the adoption of public or private water treatment, a change in modes of waste disposal—will completely eliminate fecal-oral disease. People come and go, we can't keep track of microbes, there are too many means of contamination, and technologies of purification may fail, and do, sometimes spectacularly as in the cholera epidemic in Hamburg in 1892-1893.<sup>5</sup>

#### **Regulator's Bind**

Snow, too, was fortunate in having little prior connection either to the politics of London's water or to any other institutions that threatened to disturb local social and political stability. There was no reason not to trust his science. There was no basis to brand him as one of "them"—a member of some group that uses science to take advantage of "us."

For many water professionals this will not be the case. Often the first thing people want to ask about an intervening expert is who this character is and what his or her presence portends. Environmental psychologist Michael R. Edelman has described a phenomenon called regulator's bind that arises in the practice of environmental regulation. No matter how genuine a regulator's concern for the public's well-being, that expert's statements reflect perceptions of the legal status of the problem and the willingness of institutions to deal with it, and are interpreted accordingly.<sup>6</sup>

Whether people find in

science a compelling reason to act depends more on who brings the science to the public than on the quality of the science.

Moreover, there is no magic point at which science suddenly becomes definitive. Indeed, where consequences of erroneous public action are great, the greater will be the countervailing scientific criticism generated. Water projects often do have high consequences.<sup>7</sup>

Even when we are confronted with a degree of scientific certainty, it's not always clear how to respond. Even if we accept the link of cholera and contaminated water and recognize a public obligation to prevent disease, we could make a good argument for a number of appropriate responses. The following arguments were considered in late 19th-century London and in other towns as they contemplated the construction of sanitary works.

■ Since cholera has occurred from water taken from downstream intakes, it could be prevented if the water were taken from higher upstream.

■ Since cholera has occurred from drinking water that has been contaminated, it could be prevented by purifying the water before consumption.

■ Since cholera has occurred from the contamination of the water by the excreta of cholera victims in particular, disinfection of these substances or sequestration of cholera victims will prevent the disease.

■ Since cholera comes from drinking water, it is better not to drink water; better to stick to beer, wine, tea, or bottled water.

Each argument carries assumptions about who is respon-

sible for maintaining public health, and what the possible response may be to do so.

### **Choosing a Way**

In the 19th century, the idea of taking water from upstream was the main response to Snow's demonstration. This assumes that the suppliers of water either bear responsibility for the problem or represent the most practical site for intervention. In Snow's time the suppliers of water were for-profit companies with monopolies of supply, and their interests were judged by many consumers to conflict with their own. Distrust of water suppliers made this solution the most obvious one. Under public pressure, the companies improved water intakes, and eventually, in 1901, public utilities bought out the private water companies. More recently, the supply of water in Britain has returned to the private sector, with regulatory oversight by the state. Where a water supply is publicly built and maintained, it is not clear that this would be the obvious solution.<sup>8</sup>

The second argument suggests that water should be purified before consumption rather than using upstream water that can be presumed uncontaminated. This approach shifts the burden of responsibility for purification. Should the job be contracted out, should it be the responsibility of some unit of local administration, or should it be the responsibility of the consumer? Indeed, one of the responses of the water companies to scientific explanations like Snow's was to accept his demonstration but to argue that the responsibility for purification lay with the end

user. Surely, they argued, it was wisest to purify as late in the process as possible in order to neutralize any contamination that might have occurred between waterworks and consumer. In situations where water is stored, and where there are not good household disposal methods, this may be particularly appropriate. At the same time, such an approach may be regarded, as it was by water reformers in London, as a signal to the suppliers of water that they can be reckless about water quality. If there is unequal access and application of in-home means of purification, this solution may be no solution at all, at least if the problem is perceived as a public goal of eliminating disease from a community. If, on the other hand the problem is understood as providing individuals and households with the means to avoid disease, then consumer purification may be an acceptable solution.

The third argument, for safe disposal of waste, assumes that the means are available to do so. If adequate technologies are available to treat wastes, that approach may work well. However, protection by separation of infected people is unlikely to work very well. For diseases with nonsymptomatic carriers or long latencies during which a person may be infective, it will simply be too hard to keep track of the people who are transmitting the microbe. Historically, the isolation, either of the diseased or of the non-diseased, has been one of the most frequent responses of humans to communicable diseases, and it may continue to seem an obvious

response. Certainly it requires no expensive technical changes in water supply or waste disposal, nor any bothersome changes in personal habits. In this case, as with the others, culture affects the attractiveness of the option. Where there is significant concern about the "pollution" of local society by "foreigners," such an option may be attractive. In highly cosmopolitan communities, however, it is likely to be much less so.<sup>9</sup>

Given the rise of the bottled water industry in many parts of the world in the past two decades, the fourth option, which might once have seemed to many water professionals outrageous as a circumvention of public responsibility, is again plausible. Snow himself noted that brewery workers near the famous Broad Street pump were remarkably exempt from cholera. People in many cultures and times have used various kinds of watery drinks that provide for the body's needs with less risk of water borne disease.<sup>10</sup>

It may be that people will not take any of these responses. Having heard the scientific evidence, even having heard it many times over in the most graphic language possible, people may still decide that the threat of fecal-oral disease is not high on their list of priorities: the costs of taking any action are simply too high.

### **20-20 Hindsight**

The four options outlined above were created in the context of a centralized water supply and a general acceptance by the state of a responsibility for public health. But those conditions cannot be assumed in all cases,

and where they do not exist, the range of options for providing good safe water will be even larger.

Retrospectively, things are simple: we can see that it was wise to take steps to protect the sources of water. But while our epidemiological and technical knowledge may eliminate some options and clarify the consequences of others, knowledge alone does not provide definitive solutions. Prospectively, plausible options abound. An intervener can try to craft a solution best suited to local institutions and resources, but such crafting falsely assumes those institutions and resources to be static and under-represents how much technical achievement is an art of practical local politics.<sup>11</sup> It also betrays the intervener's own estimation of whose interests matter most and may well generate opposition and fall victim to the problems that generally plague turnkey approaches.

When we focus in on the historical experience of achievement in water and sanitation, we find that the best technical solutions are less important than the questions of who benefits, what the implications are for structures of power and society, and whose knowledge can be trusted. This is the case not merely for the developing world, but for the developed as well.<sup>12</sup> While the public reasons for improvement of water tend to focus on health, need, and amenity, other factors often count more, such as who owns what land, which areas will be served, what labor will be employed, and whose political power will be enhanced by a

water project. While engineers and development workers learn to operate effectively in such contexts, engineering rarely recognizes the skills that lie beyond technical knowledge.

### **Community Action**

"Own key" solutions to local water problems are by no means incompatible with the involvement of outside experts. But the expert's role will be different. Most who work on public projects in cultures other than their own agree that it's important to be well versed in local ways. There is less agreement about what to do with that familiarity. Should one be a resource person, available for help once a community has decided, on its own, to embark on some project, or rather should one be an active partisan? If there is a lesson from history, it is that we should not idealize community decision-making and that there is no role which is not partisan in some way. In any community there will already be a sanitary politics, a distribution of power. Often hygienic improvement required appealing to many constituencies with many diverse reasons. The intervener with a sense of the complex history of sanitary improvement, as well as a sense of local social structure, and some appreciation of ethnographic theories and methods, will be much better positioned to intervene effectively to improve water quality.<sup>13</sup>

It is probably unrealistic to expect periurban settlements in the developing world to follow the same evolutionary path as towns in the developed world have done. Often the capital required is not available. Nor are

the institutions that guide the expenditure of capital up to the job. Nor for that matter are the water-intensive solutions of the developed world the ideal solutions to problems of sanitation elsewhere. Under these circumstances, it may seem that there is little we can do but stand by and watch. Yet there was and is more to successful sanitation than plenty of money and a powerful state. It would be as wrong to write off periurban communities in the developing world as too poor and anarchic to solve problems of sanitation as to think that they will and should recapitulate the sanitary achievements of urban settlements in the developed world. If public health experts from the North are to contribute to this achievement, they should draw on parts of their history and professional identity that have been suppressed: their ability to *engage* in politics, not to circumvent it with scientific authority. What is now necessary is to recover these lost strains of professional heritage, bring them back into professional education, and rethink the identity of the professional sanitarian in a post-colonial age.■

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# ■ ■ ■ DIALOGUE

## Natural Values

The world famous Sarvodaya Shramadana movement in Sri Lanka is one of the world's largest and most successful grassroots community organizations. A.T. Ariyaratne, its founder once said, "When we try to bring about change in our societies, we are treated first with indifference, then with ridicule, then with abuse, and then with oppression. And finally, the greatest challenge is thrown at us. We are treated with respect. This is the most dangerous stage."

Indeed, the growing respectability of sustainable development, the increasing number of corporations for whom sustainability is now on the radar screen, and its increasing political correctness concern John Ehrenfeld ("Being and Havingness," FORUM, Winter 2000). How deeply do corporate and political leaders grasp the real questions lying at the heart of sustainability, let alone the implications for our products and business models?

For example, many now embrace eco-efficiency or re-source productivity. But clearly,

eco-efficiency innovations alone cannot avert environmental crises. Business people are drawn to eco-efficiency for the same reasons they are drawn to all other types of efficiencies. Improved efficiency means improved profitability. But what will happen to those profits? They will be reinvested. In today's global capital markets, profits from improved eco-efficiency will flow into the most profitable new investment opportunities, most of which remain decidedly eco-inefficient. Moreover, most eco-efficiency improvements are in production technologies. These innovations do not affect what happens to products after sale, the waste created from their use, and their eventual disposal. Again, increased eco-efficiency profits will lead to more growth and more waste.

To put it bluntly, nature does not care how efficient our industrial system is; she cares how much waste it generates in absolute terms. At best, innovations in eco-efficiency offer a starting strategy. At worst, they serve to relieve the psychological stress of living in unsustainable ways and thereby enable us to

continue to live in these ways.

Despite his stature in industrial ecology and years of work with leading industrial designers, Ehrenfeld clearly eschews the naïve view that our environmental crises have technological roots and consequently technological solutions. Rather, he points to the cultural roots that shape the technology we create and use—specifically our substitution in the modern age of things for relationships, of possessions for quality of life, of "having" for "being."

Yet Ehrenfeld is no Luddite. His message is more subtle. He believes we can create a genuinely sustainable society by integrating three world views that have typically been at odds in the modern age—the rational, the human, and the natural. Efforts to resolve our current predicaments through only one dimension, like rationalistic technology or returning to nature, will fail.

In pointing in these three directions, Ehrenfeld reiterates the wisdom of the most successful cultures in human history, that mental, emotional, and physical principles are necessary codeterminants of true develop-

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ment. For the ancient Greeks, it was the true, the good, and the beautiful. For the ancient Chinese, it was Buddhism, Confucianism, and Taoism, which are respectfully centered on the mental, interpersonal or social, and physical dimensions. In effect, Ehrenfeld is asking how we can rediscover these guiding principles and bring them back into the mainstream of the contemporary world.

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## The Future of Aging

**K**udos to Pete Peterson on identifying one of the great challenges of the 21st century—global aging—in “The Next Century’s Greatest Challenge” (FORUM, Winter 2000). Projected declines in the number of workers in most advanced nations reduce not just the tax base for Social Security-like programs, but overall the rate of growth of economic output as well. Tax revenues that go for education, health programs for the aged, defense programs for everyone, and other social needs are also projected to decline with less growth in economic output.

Peterson is sometimes accused of addressing this issue from a

Wall Street perspective, but that is an unfair accusation. However aging problems are tackled, few benefits are likely to accrue to Wall Street, and, even if some do, it will be long after Peterson is gone from that scene. Peterson recognizes that government can’t constantly promise more resources than can be found to meet society’s needs. And the principal resource involved is not savings or physical capital, but labor and what is sometimes called human capital. In the end, he reminds us, we must produce what we want to consume.

The aging label can be misleading, however. Aging of the population refers to two very different phenomena: longer lives and reduced birth rates. It is not clear that living longer is really aging at all. If, as President Clinton once suggested, some people born at the end of the past century can expect to live to age 100, does that mean they are old at 60 or 65? If being old is defined as closeness to death, then are people who retire with 15, 20, and more years of life expectancy really old? On the other hand, declines in birth rates do mean that a larger percentage of a population will be in later stages—in the last half or fifth of their lives. In that case, an increased share of societal resources will be required to meet the needs of the elderly.

Society can adapt, and adapt well, but only if institutions are reformed to allow that adaptation to take place. For over half a century, developed nations and some lesser developed ones as well have put up more and more barriers to work among those in late-middle age and beyond.

Some barriers are the result of public programs, some result from policies such as seniority pay scales that reflect poorly the relationship between productivity and age. Within a few decades, close to one-third of the population of the United States will be receiving Social Security, as people retire for more than one-third of their adult lives. This scenario, I believe, will be countered in part by a demand for older workers and, to some extent, for immigrants.

The notion that one gets educated for 12 to 16 years, except afternoons and Sundays, is a reflection of a 19th century farm economy. The industrial economy notion—that education stops and work begins for some span of middle years, while both education and work stop at a fixed age like 62 or 65—is also rapidly becoming antiquated. These views do not reflect either the demands or the wants of an information and technological society. Instead, society is already starting to find ways to integrate education, work, and leisure not just by age but by place. Thus, in the future, people will increasingly want to participate in all these activities at all ages and often at the same place, for example in the workplaces of a knowledge economy. But these adjustments require removing many institutional barriers, and it is to these tasks that Peterson correctly calls us. The challenge becomes a crisis only if we close our eyes to the possibilities.

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## Moving On

In “The Retirement Rush” (FORUM, Winter 2000), William H. Haas III and William J. Serow argue that the baby boomers may break the mold of retirement patterns. Retiring boomers may migrate differently from preceding generations not only because of the larger size of the birth cohort, but also because of differences in pension plan accumulations and a flat real estate market.

The baby boom, however, is extremely diverse, and that diversity may affect patterns of retirement migration. Because of greater educational achievement, the growth of the service economy, and dramatically rising numbers of working women, there will be more retired couples with two careers. This will create a complex set of retirement income streams. Some couples may receive two Social Security checks, one or two pensions, investment income of various kinds, and perhaps inherited wealth to boot. These two-career couples will represent the upper end of the income distribution scale. If they have traveled and vacationed widely, they may be even more likely to move upon retirement.

On the other hand, the higher divorce rate, greater economic independence of women, and the tendency for children to stay with their mothers after divorce mean more families among baby boomers consist of mothers and their children. Collectively, the per capita income of these households is relatively low. The baby boomer generation, therefore, is skewed toward the upper and

lower ends of income distribution, with fewer in the middle. As a result, there should be more, not fewer, affluent baby boomer retirees choosing to relocate upon retirement.

Yet more baby boomers will opt to retire later or launch late-life second careers, as Haas and Serow note, taking them out of the migration market. We are also likely to see more retirees move, and perhaps to unusual places such as Wyoming, Utah, and Colorado in the “new West,” and New England, the Upper Peninsula of Michigan, and Oregon, during the 2010s and 2020s. In addition, retired baby boomers may travel as volunteers or educators, rather than settle permanently in a retirement community. However, the flow into established migration destinations will continue to increase through the 2020s. On the downhill side of the baby boom, retirement migration is likely to constrict severely. Planners considering retirement communities as a development strategy should take the long view and envision this scenario as well.

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## The Rural Health Care Divide

Because of their lower socioeconomic status and greater financial and health needs, older Americans living in rural areas rely more heavily than their urban counterparts on governmental programs such as Social Security, Medicare, and Medicaid. In “The Graying of Rural America” (FORUM, Winter 2000), Carolyn Rogers reminds us of the importance of meeting the needs of the rural elderly. Until recently, however, neither federal nor state government policies have taken into account the special needs and circumstances of the rural elderly and of the health and social systems they rely upon. So where should we focus our attention?

Restructuring the Medicare program is likely to be high on the agenda in the new Congress as President Bush seeks to make good on his promise to provide prescription drug coverage for seniors. My colleagues and I have examined proposals for prescription drug expansion offered in the 106th Congress and have found that the designs of these varied programs could have very different impacts on rural seniors and rural health systems. For example, the significant economic differences between the rural and urban elderly mean that income eligibility levels and the level of cost sharing—premiums, deductibles and co-insurance—will be critical in determining the extent of this benefit for the rural elderly.

Moreover, many rural older persons rely more heavily on

Medicare and other government programs than do their urban counterparts, and so do rural health care providers. Medicare payment policies will have significant implications for the sustainability of rural health systems. The next Congress will continue to debate whether Medicare provider payment policies are adequate to sustain local rural health systems.

Since the mid-1980s, Congress has devoted increasing attention to the needs of rural health care providers. The most recent budget bill—the Medicare, Medicaid, and State Childrens’ Health Improvement Program Benefits Improvement and Protection Act of 2000—contains numerous provisions addressing the needs of rural health care providers. Yet, if significant shortfalls in Medicare funding occur, the underserved rural communities and populations could easily fall through the cracks.

In addition to assuring that Medicare policies support rural people and health care systems, we need to start discussing the long-term care needs of rural populations that have been largely ignored by state and federal policymakers. Rural elders have fewer resources to pay for long-term care services out of their own pockets and are therefore more dependent on Medicare, Medicaid, and other public programs. Numerous studies have shown that older people in rural communities are more likely to rely on nursing home care and generally have poorer access to home and community-based services.

A number of states, including Oregon and Wisconsin, have led

the way in developing long-term care systems that expand options for home and community-based services. Yet public funding of long-term care can’t meet the growing need. Assuring that underserved rural communities and older people receive their fair share of public funding for these services will be critical for improving the capacity of the rural long-term care system to meet the growing needs of rural seniors and their families.

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## Targeting Research

**W**e already have in place laws against practically every form of criminal use of a firearm. Most researchers, therefore, find the faith of gun-control proponents in legislative attempts to curb firearm-related crime misplaced. As Timothy Brezina and James D. Wright note in “Going Armed in the School Zone” (FORUM, Winter 2000), there is little more that legislatures can do—short of radically changing our notion of government—to get guns out of the hands of kids and adult offenders.

Gun-control advocates generally are bright, well educated, well-intentioned people. Why then do they propose legislation that simply replicates existing law or otherwise fails to put a

dent in the gun problem? Why do they not embrace the conclusion of their opponents—who are also generally well educated, bright, and of good intention—that we need less new law and more enforcement of current law?

First, contemporary anti-gun legislation is less about content than about achieving victory by passing laws. The symbolic value of breaking the gun lobby’s hold over legislators, in the view of gun-control advocates, is paramount. Second, as studies have shown, in any practical sense simply enforcing laws will not reduce levels of gun-related crime, at least not for very long.

Public opinion polls find most Americans favor some form of gun control and want protection from criminals. They leave it up to their legislators to determine how to accomplish this. What legislators propose, sometimes disingenuously, is generally dictated by the pro- and anti-gun-control lobbies. At one extreme are those who consider guns responsible for high levels of crime and accident-related injuries. They envision a society of relative peace achieved through banning ownership of most types of firearms. At the other pole are those who believe that if guns are outlawed, citizens will be impotent in the face of military occupation, will have no recourse to abuses of power by their own government, and will be unprotected from violent criminals.

Ironically, to accomplish either extreme’s vision would entail serious movement toward a Big Brother state. To scrub clean of guns a society that has permitted ownership on a

massive scale cannot be accomplished without ceding yet more power to government. To eradicate gun-related crime through stronger law enforcement cannot be accomplished without granting police nearly the powers of an occupying force.

Legislators cannot afford to ignore pressure by the lobbies in question. Researchers have a bit more freedom. We need not limit ourselves to analyzing the potential outcomes of the softballs that legislators continue to lob. Brezina and Wright correctly ask us to turn our attention less to the contentious issue of gun control and more to the obstacles to social and personal success. Social stress and personal antagonisms that provoke or escalate aggression are the conditions that lead to gun carrying and law breaking in the first place. This will require more-relevant, but clearly more-difficult and controversial, research.

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## Disarming Canada

**T**he right to defend oneself and one's family against violent attack is fundamental. In "Self-Defense: The Equalizer" (FORUM, Winter 2000), Linda Gorman and David B. Kopel succinctly explain why gun-control legislation does not improve public

safety but instead increases the chances of violent crime. The authors argue persuasively that gun control is a dangerous path to follow for democratic governments, as it is fundamentally inconsistent with individual freedom.

Gun-control advocates have a distrust of the typical person. The key assumption is that access to firearms will somehow cause otherwise law-abiding citizens to become violent. This is false and pernicious reasoning. Studies from around the world show that violent criminals are not normal people. For example, Canada's national statistical agency, Statistics Canada, recently found that the typical Canadian murderer, like his counterpart in the United States, has a long history of criminal violence.

The authors are on solid ground when they state that gun-control laws cannot abolish violent crime. There are no reputable studies in any country in the world that show that firearm restrictions significantly reduce violent crime. When the medicine doesn't work, the solution is not more of the same medicine. Rather one needs to rediagnose the problem.

There is good evidence that allowing people to defend themselves improves public safety. Over the past 20 years, many states in the United States have passed laws allowing responsible citizens to carry concealed handguns. The result has been that crime rates have dropped faster in those states than elsewhere.

In sad contrast, gun-control laws in countries such as Canada have made it more difficult for people who need firearms for

protection to have them available when they need them. Despite governmental attempts to discourage the use of firearms, at least 80,000 Canadians each year use firearms to defend themselves or their family against violent attack.

Governments find it all too easy to increase their powers by exploiting public fears. In Canada, the latest round of gun-control legislation not only introduced owner licensing and firearm registration, it also seriously eroded the legal rights of all Canadians. The new law gives police greater powers of search and seizure, and it allows a variety of new officials to enter homes without search warrants to inspect firearm storage or to look for unregistered firearms. Suspected gun owners are even required to testify against themselves.

Governments do not seem to know when to stop. Only weeks after Canadians were required to have a licence to keep previously purchased firearms, the Royal Canadian Mounted Police began confiscating firearms on the basis of anonymous complaints that they do not have the newly imposed licence.

Despite draconian restrictions, gun-control laws have not had a significant impact on criminal violence. One can only hope that Americans learn from the experience in other countries that gun control is a slippery slope to sacrificing individual liberty as well as personal safety.

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