What We Stand to Lose in the San Acacia Floodway

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Water resource issues in the Middle Rio Grande are complex and interlinked, and nowhere more so than in the San Acacia reach. It is difficult to develop solutions to comprehensively address the management of interconnected water, land, and ecosystem resources within the middle valley, given the differing expert viewpoints on resource needs and priorities, the different physical characteristics of each reach, and possible unintended consequences of particular solutions. Many decisions have been driven by a specific event or regulatory mandate and are generally aimed at the most dire pending disaster. Management of river flows in the Middle Rio Grande valley entails a balance of competing interests and safety issues. In the face of potentially disastrous high river flows, we have to act immediately to prevent breach of a levee and protect humans, infrastructure, and the environment. On the other hand, how can we better manage high flows to provide benefits to the environment, the river channel, and the long-term functionality of the river system? How does a decision maker prioritize competing interests and decide what to support and what not to support? The cost of extended inaction in the San Acacia reach is loss of the agricultural, environmental, and economic productivity of the San Acacia reach as well as much of the Middle Rio Grande. In this paper we describe one successful outcome from recent work conducted in the San Acacia reach and illustrate a possible worst-case scenario and its potential impacts.

CHALLENGES AND OPPORTUNITIES OF THE 2005 FLOW EVENT

During periods of low river flow, the U.S. Bureau of Reclamation, the New Mexico Interstate Stream Commission, and other agencies coordinate on floodway projects that reduce flood risk, aid in routing water safely through the middle valley, and control natural water losses. Currently these projects include construction and recurring maintenance of the pilot channel, selective reinforcement of river levees, maintenance of drains, and removal of sediment plugs from the river. During high river flows, the Bureau of Reclamation and the U.S. Army Corps of Engineers implement their emergency response capabilities, respectively, by shoring up levees and implementing other short-term fixes and initiating flood-control operations from upstream reservoirs. Over the past five years, the average cost of such work within the Middle Rio Grande floodway has exceeded $10 million per year in state and federal funds. Although these efforts have reduced flood risk, the flood threat to adjacent lands remains throughout the Middle Rio Grande floodway, including the San Acacia reach. There are historical, naturally flood-prone areas, and both engineering and natural events affect flood potential in a number of ways. These include channel narrowing, increased vegetation density and encroachment into the river channel, aggradation of river sediment, disconnection of tributary arroyos, deteriorated levees and non-engineered levees, and infrastructure in the floodplain such as residential development and the San Marcial railroad bridge. These areas constrain the rate of safe releases from upstream reservoirs.

During spring 2005 the Middle Rio Grande basin experienced the highest snowmelt runoff in about 10 years. To accommodate the high flow, the Corps of Engineers attempted to reach the maximum authorized safe-channel-capacity release from Cochiti and Jemez Canyon Reservoirs. The corps was able to maintain a high release for an extended period of time, primarily due to the preventative and emergency repair work by the Bureau of Reclamation during the runoff, and successfully managed potentially disastrous flood flows, accruing a number of benefits to water users, endangered species, and the ecosystem.

The successes of 2005 were many. Through skillful management of flood flows and a small dose of serendipity, the corps was able to maintain the high consistent flood release for several weeks without a levee breach. As a result, significant overbank flooding occurred within the Middle Rio Grande bosque, and the Article VII storage prohibition of the Rio Grande Compact was lifted on the day of peak runoff into El Vado Reservoir. Lifting of the storage prohibition allowed the Middle Rio Grande Conservancy District (MRGCD) to store more than 120,000 acre-feet of water in El Vado Reservoir with about 80,000 acre-

feet of that storage occurring in the ten days immediately following the peak. The storage in El Vado Reservoir provided water to farmers and helped sustain river flows for the silvery minnow during fall 2005 and 2006. However, if the 2005 flood releases had been further restricted or a levee had been breached anywhere in the valley, a very different scenario might have played out: The storage prohibition would not have been lifted in May, MRGCD would not have amassed adequate storage in El Vado Reservoir, significantly reducing water deliveries for farmers and the minnow, and flooding may have occurred outside the levee system in vulnerable areas of the Middle Rio Grande Valley.

Erosion of river bank at river mile 111, just a few miles below San Acacia, due to high snowmelt runoff in spring 2005. The river is migrating laterally to the left, toward the cut bank.

The maximum flood release in 2005 produced a flow of about 6,000 cfs at San Acacia, providing significant benefits to the river channel and riparian habitat in some areas, but increasing flood risk in others. Overbank flow inundated some areas of cottonwood bosque that hadn't been flooded in several years, rejuvenating the riparian system and the Rio Grande silvery minnow. Adult minnow catches in the Middle Rio Grande in fall 2005 were some of the highest on record. Where it occurred, scouring of the main channel stripped congested vegetation from sand bars, thus helping to maintain an open channel. While scouring increased flow capacity in some areas, it also increased flood risk where erosion allowed the river to migrate laterally toward a levee. The Low Flow Conveyance Channel and adjacent levee have been moved back from the river in one location south of San Acacia to reduce flood risk by accommodating greater migration of the channel. Sediment scoured by high flows in upstream reaches was deposited in downstream reaches, plugging the river channel for almost two miles near Tiffany, four miles south of Bosque del Apache National Wildlife Refuge, and severely straining the adjacent levee. Emergency measures were conducted during the high flows, and the sediment plug was excavated in the fall of 2005. The unfortunate reality is that the Corps of Engineers cannot release sufficient water to cause inundation of the bosque in the Cochiti and Albuquerque reaches without increasing the flood risk through Isleta and San Acacia.

The 2005 water season also produced benefits to downstream users. Due to the high inflow to Elephant Butte Reservoir during the spring of 2005, the water elevation in the reservoir rose sharply, and recreation interests experienced a relatively good year. The Bureau of Reclamation allocated a nearly full supply of surface water for the Elephant Butte Irrigation District, the El Paso County Improvement District No.1, and the Republic of Mexico.

A WORST CASE FLOOD SCENARIO FOR THE SAN ACACIA REACH

Despite the successes of 2005, another flood scenario threatens the Middle Rio Grande valley—one with a less beneficial outcome—if we fail to comprehensively manage water, sediment, and riparian system function. The Rio Grande is sediment-laden with vast sources of sand, silt, and clay immediately available in its adjacent terrain. A worst-case scenario for the San Acacia reach can result from a combination of sediment load and high flood flows from record snowmelt runoff or intense summer rains similar to those experienced in summer 2006. South of Highway 380, the river is actively building up its channel with sand deposited from its sediment heavy waters, and it will continue to aggrade. In response to a high flow event, we anticipate that the river will again become plugged with sediment near Tiffany, as it did in 2005. What happens next depends on our level of preparation, our ability to respond, and the whim of Mother Nature. If

Aerial view of the sediment plug near Tiffany in spring 2005, when the plug formed. The Low Flow Conveyance Channel is visible on the right; Black Mesa is visible at the top of the photo.

A close up of the sediment plug near Tiffany in fall 2005. The excavation in the center of the photo has revealed the location of the water table, several feet below the surface of the plug.

we are unlucky and the river cannot scour a path through its clogged channel, then the sediment plug will become vegetated, and the river channel will effectively disappear. When this happened in the 1950s, various pilot channels and the Low Flow Conveyance Channel were constructed over a number of years to facilitate movement of water and sediment to Elephant Butte Reservoir. If this scenario were to be repeated today, the human and environmental consequences would be disastrous in comparison.

A flood of the future—As sediment builds up or aggrades the river channel south of Highway 380, possibly becoming congested with dense vegetation, private land and homes upstream on the east side will be vulnerable to flooding at lower river flows. Land and homes on the west side of the Rio Grande have a lower flood risk because of limited protection provided by the spoil-bank levee adjacent to the Low Flow Conveyance Channel. The magnitude of reservoir flood-control releases available will likely decline because of levee integrity issues in the San Acacia reach. Ultimately, a high flow from the uncontrolled watersheds of the Rio Puerco, Rio Salado, or both, possibly in combination with an already high reservoir release flow, will cause a levee failure somewhere south of San Acacia. Once out of its banks, the river will quickly fill the Low Flow Conveyance Channel with sediment, flow from the failure point toward low-lying areas of the valley, and then erode through its existing channel in an upstream direction, while spreading floodwaters into the Socorro valley.

New Mexico's compact deliveries—In part because the river channel ceased to exist near Tiffany in the late 1940s and early 1950s, New Mexico's water deliveries to Elephant Butte Reservoir suffered. New Mexico was out of compact compliance from 1948 through 1968, and Texas filed suit against New Mexico in response. Due to reductions in the quantity of water reaching Elephant Butte Reservoir, usable storage fell below 400,000 acre-feet and Article VII compact restrictions on upstream storage were in place in many years, reducing the surface water available for use by MRGCD and Santa Fe from 1950 until about 1980. Future flood damage to conveyance works in the San Acacia reach would again degrade our ability to convey water to Elephant Butte Reservoir, with potential outcomes not unlike those that occurred in the 1950s, 1960s, and 1970s.

The surface water supply and agriculture—For farmers in the Socorro Division of the MRGCD and at the Bosque del Apache NWR, the immediate impact of a levee failure would depend on the location of the failure. If the failure occurred downstream of Bosque del Apache National Wildlife Refuge, the human and environmental impacts would be minimized. A water table rise would develop in the floodplain from clogging of the Low Flow Conveyance Channel and nearby drains, ruining crops and irrigable lands. If the failure occurred in the main farming area north of the refuge, many low-lying farms would be inundated and filled with sediment or waterlogged. As the MRGCD drainage system became clogged or overloaded or both, affected areas would become unusable. Surface

water supplies would be limited for farmers outside of the Socorro valley in the Elephant Butte Irrigation District, Texas, upstream in the MRGCD, and for citizens of Santa Fe.

Endangered species—Both the Rio Grande silvery minnow and the southwestern willow flycatcher would be imperiled by an extreme flood event. The river channel downstream of a levee failure would dry, and fish residing in that reach would die. The river channel upstream of a levee failure would incise, or lower in elevation as water and sediment flowed out into the valley. Some fish would be carried onto the inundated floodplain, and aquatic habitat in the incised reach would be significantly altered. Existing and suitable southwestern willow flycatcher habitat would be impaired if channel changes eliminated nearby moist substrate and open water that provides favorable nest sites. Finally, if upstream storage in El Vado Reservoir is restricted, less water would be available for release during normal periods of low river flow, and the San Acacia reach would be more prone to channel drying.

Bosque and riparian health—The long-term viability of the cottonwood bosque, historic east side wetlands, and other riparian vegetation would also be jeopardized during a worst-case flood event. Where the river channel has aggraded and is perched above the floodplain, a levee failure would cause the river channel upstream to incise, or lower in elevation, and the downstream channel to dry as water and sediment flowed out into the valley. Both channel incision and river drying would lower the water table, and many native trees would die if the water table dropped below the active root zone. In low-lying areas that cannot be reclaimed when floodwaters recede, salt cedar and other invasive species we have been trying to eradicate could move in and overwhelm the flooded areas.

CAN WE PREVENT A WORST-CASE FLOOD SCENARIO?

If a worst-case flood scenario comes to pass, there will be little hope of restoring the agricultural, environmental, and economic productivity of much of the San Acacia reach. It is not certain whether this future flood disaster can be prevented unless some large-scale project is implemented. We do know that the federal and state dollars currently allocated are insufficient to keep up with the number of priority sites in the middle Rio Grande.

The Bureau of Reclamation, the Corps of Engineers, and the Interstate Stream Commission annually request funding to address flood potential in the Middle Rio Grande. Reclamation currently requests approximately $8 million per year for design, permitting, construction, and monitoring of flood-control projects. Except for about $20 million in congressional funding several years ago (used to buy new equipment, relocate the Low Flow Conveyance Channel and levee near San Acacia, and implement a few other high priority projects), the federal budget has been flat. Although the Bureau of Reclamation has used the funding to construct a number of fixes, the number of priority sites keeps rising. Currently, the Bureau of Reclamation lists 26 priority levee sites in the Middle Rio Grande Project. Examples of priority sites in the San Acacia reach are located at river miles 113 and 114 and the Tiffany area, where projects to relocate or raise the levees and/or realign certain sections of river are planned. Additional priority projects include removal of sediment plugs, widening the river channel, and maintaining the Elephant Butte delta pilot channel.

An amphibious excavator clearing the Tiffany plug in fall 2005.

State and federal partnerships on collaborative projects are essential for managing and preventing flood disasters in the Middle Rio Grande valley. The Corps of Engineers oversees and directs operations of the river and reservoir system during certain high flow events, implements flood fighting activities, and aids state and county emergency managers. The federal agency also has the capacity to design and build engineered levees and various flood-control facilities to protect farmland, homes, and cities. The Interstate

Stream Commission provides a federal cost share for selected levee projects and annual floodway maintenance, focusing its efforts in areas that are outside of federal or MRGCD scope. The agency also excavates the lower 11 to 15 miles of the Elephant Butte pilot channel and conducts projects with the Bureau of Reclamation to maintain river conveyance (like removing the Tiffany sediment plug). The Interstate Stream Commission has spent an average of about $2.8 million per year over the past five years on such activities. The MRGCD is generally responsible for maintaining the levees within its boundaries.

Forging a Sustainable Water Policy in the Middle Rio Grande Valley—a Downstream Perspective

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The strategy where one jurisdiction tries to achieve water solvency at the expense of a neighbor is generally unpalatable and strictly prohibited in the Interstate Stream Commission's regional water planning guidance. In the final analysis, what does the state of New Mexico do when the Middle Rio Grande region has garnered the entire valley's water yet continues to demand more?

The face and character of the Middle Rio Grande valley have changed over time, as all things do. Most of the changes were not planned; rather, they happened gradually. In the coming decades change will continue to accelerate and threaten the economic base and cultural identity of the valley's rural communities.

New Mexico is a water-limited state and since the 1990s has been one of the fastest growing states in the nation. Explosive population and commercial and economic growth in the Middle Rio Grande valley have been deemed lucrative, progressive, and inevitable and have fueled a market-driven competition between cities and farms for the rights to use the limited waters of the Rio Grande and its adjacent aquifers. The collective demands of growth, environmental and ecologic needs, ever-increasing ground water pumping and stream depletion, system inefficiencies, and the unknown risk of climate disruption threaten to force default on New Mexico's contract to deliver water to downstream users in southern New Mexico and Texas. Consequences of the boom loom large for cities, counties, water utilities, rural and agricultural areas, the environment, and the present distribution of water rights. With limited opportunities to develop or import new supplies, new uses must rely largely on water obtained from changes of existing uses. In the Middle Rio Grande valley, the reallocation of water to "higher valued uses" is accompanied by adverse consequences for rural communities, agriculture, and the environment, all of which must be considered.

WATER POLICY AND PLANNING—MITIGATING NEGATIVE CONSEQUENCES OF GROWTH

As water use moves from farms to cities, it can trigger unforeseen social, economic, and environmental consequences that impact the quality of life for all who live in the Middle Rio Grande valley. Over-appropriation; hydrologic imbalance; the decline of agriculture; environmental, ecological, and recreational impacts of dwindling surface water supplies; and degraded water quality—these are all things that happen when you transfer large blocks of water rights from place to place over long distances and from surface water to ground water. The enormity and interconnection of these issues underscore the inter-relationships of growth, sustainability, and water policy. Although decisions about how or where to grow are rarely influenced by either water policy or availability, there is little question that future growth must consider natural resource constraints.

The realization that both water and our capacity to grow are limited is not new. Neither is the effort to develop plans that promote orderly transitions and alleviate unwanted consequences that are sure results. A comprehensive look at the impacts and options regarding growth by the New Mexico Department of Finance Administration concluded in 1996 that "we are a water limited state…we are all wildly borrowing against the future…[P]erpetual growth…is impossible for New Mexico…why are we afraid of statewide planning?"

The Western Governor's Association, in their 2006 report on *Water Needs and Strategies for a Sustainable Future*, made these pertinent recommendations promoting fairness, balance, and sustainability in growth policies:

- States should identify water requirements needed for future growth, and develop integrated growth and water supply impact scenarios that can be presented to local decision makers.
- States should facilitate collaborative watershed-focused planning that balances desirable growth and protection of the natural environment, which depends on surface and ground water quantity and quality.
- In reviewing applications for new water uses, transfers, and changes in use, including in-stream flows, states should consider local, tribal, and

watershed plans and decisions regarding growth management.

- States and local government should consider the impacts of continued growth that relies on transfers from agriculture and rural areas, and identify feasible alternatives to those transfers.

Each recommendation embraced local or watershed-scale collaborative planning and the involvement of state and local government in developing solutions that balance sustainable growth and water use. The first recommendation has generally been accomplished in New Mexico; the remaining three have barely advanced beyond the level of round-table discussion. Although growth management has primarily been a local matter, states have a critical role to play. The state engineer has the primary responsibility for water allocation and management, and the jurisdiction to sanction or restrict the transfers of existing uses that fuel urban growth. The state engineer and the Interstate Stream Commission also have authority and responsibility for initiating and assisting water planning on both a regional and state level.

In 1986 a federal court decision (*City of El Paso ex rel. Pub. Serv. Bd. v. Reynolds, 563 F. Supp. 379 (D.N.M. 1983)*) upheld a challenge from El Paso to a state statute prohibiting export of water to Texas. The decision provided: (1) that an out-of-state applicant proposing to appropriate New Mexico's ground water must prove that all efforts at conservation have been exhausted; and (2) that the New Mexico state engineer could reject an out-of-state water rights application where New Mexico could show that local water was needed to meet projected demands. In response to this decision, the New Mexico legislature in 1986 appointed a team of experts to investigate the status of the state's water resources and its relationship with future demand. The investigation kicked off New Mexico's water planning effort and found, among other things, that:

- Even with extensive efforts toward water conservation, the effects of converting surface water rights from agriculture to municipal and industrial uses would weaken the agricultural economy significantly in a relatively short period of time. With significant (25 percent) water conservation, the Middle Rio Grande was projected to lose 10 percent of its agricultural water rights by 2003, 25 percent by 2033, and half of its agricultural water by 2071.
- Transferring water to areas of the state needing to import water "will create conflict between the source area and the area to which the water is transported."
- "There may be areas of the state that need preservation because the culture or the land or both constitute irreplaceable assets. [I]t is unwise to allow the very best agricultural lands to go out of production. … Agriculture may not be able to compete with municipalities and other industries for water from a strictly economic viewpoint. Yet, the long-term interest of the state may best be served by sustaining a healthy agricultural industry in selected areas."
- The state should work in partnership with each region to develop a series of regional water plans, compile regional plans into a state water plan, and form state-regional partnerships for water development and cooperation in promoting water conservation.

Twenty years later, the products of this foundation are sixteen regional water plans that quantify water supply and demand and that identify possible regional solutions to rectify supply-demand gaps. In 2003 legislation was passed that authorized the State Water Plan to be "a strategic management tool for the purpose of:

- Promoting stewardship of the state's water resources;
- Protecting and maintaining water rights and their priority status;
- Protecting the diverse customs, culture, environment, and economic stability of the state;
- Protecting both the water supply and water quality;
- Promoting cooperative strategies, based on concern for meeting the basic needs of all New Mexicans;
- Meeting the state's interstate compact obligations;
- Providing a basis for prioritizing infrastructure investment; and
- Providing statewide continuity of policy and management relative to our water resources."

The State Water Plan, completed in 2003, provides guidance and policy on the linkage between land and

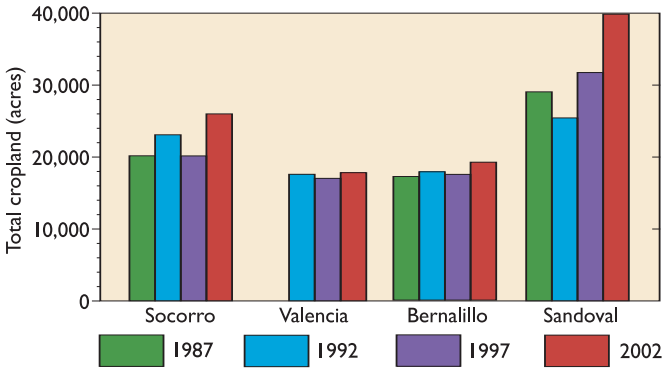
water use. Policy statements in the State Water Plan mimic the Western Governors' Association recommendations and require "consideration of the relationship between water availability and land-use decisions" and water rights transfer policies that "balance the need to protect the customs, culture, environment, and economic health and stability of the state's diverse communities while providing for timely and efficient transfers between uses." Pursuant to legislation, the State Water Plan is to be updated in 2008.

REGIONAL CONFLICTS AND LAND USE ISSUES IN THE MIDDLE RIO GRANDE VALLEY

Strategies to manage growth, conserve water, develop new water supplies, protect water quality, and protect quality of life have emerged in regional water plans where water resources are insufficient for existing or projected growth or where cultural impacts exist with respect to water transfers. Projects have been identified statewide, but local know-how, funding, and guidance from the state are often lacking, and many regions are uncertain about how to proceed with implementation. One serious obstacle to plan implementation is resolving disparities between plans and conflicts among regions relying on the same water source. Nowhere in the state are the consequences of not implementing solutions more serious than in the Middle Rio Grande valley, and regional water plans provide a road map, albeit a sketchy one.

Three water-planning regions, each with a recently completed water plan, lie along the Rio Grande between Otowi Gage and Elephant Butte Reservoir: Jemez y Sangre (Santa Fe, Los Alamos, and Rio Arriba Counties), the Middle Rio Grande (Sandoval, Bernalillo, and Valencia Counties), and Socorro–Sierra. To these adjoining constituencies, the real possibility of defaulting on Rio Grande Compact obligations presents a common dilemma, for compact debits and credits apply equally to all three, and a water-budget deficit incurred in one segment affects each of the others. The annual average basin-wide shortfall is currently estimated at 40,000 acre-feet in surface flow; an additional 71,000 acre-feet in aquifer depletions is poised to impact the Rio Grande within the current planning horizon (see paper by Hathaway and MacClune in this volume).

A closer look at regional water plans and budgets is revealing. Although region-specific budgets indicate that each region is operating under a negative water balance (regional consumptive use exceeds regional inflow), the ever-increasing basin-wide deficit is largely a result of unfettered growth and ground water withdrawals in the Middle Rio Grande planning region. Being on the downstream end, the Socorro–Sierra region inherits the Middle Rio Grande valley's debt in the form of reduced inflow, and the region's outflow reflects the projected basin-wide budget deficit of 40,000 acre-feet. To offset their deficit, the Middle Rio Grande planning region proposes to rely, in part, on water purloined from neighboring regions, particularly Socorro and Sierra Counties. The Middle Rio Grande water plan seeks to increase regional supply within the next 50 years by purchasing water rights and ultimately drying 12,500 acres, or approximately one-half of the irrigated cropland remaining in Socorro County, and by transferring salvaged water from 17,500 acres of restored bosque.



Total cropland in the Middle Rio Grande valley, 1987–2002. Census data indicate that total cropland has remained steady in Valencia and Bernalillo Counties and increased in Socorro and Sandoval Counties, even while water rights are transferred from irrigated lands for other uses. Data is from U.S. Department of Agriculture's 2002 Census of Agriculture, conducted by the National Agricultural Statistics Service.

Implementation of the Middle Rio Grande plan would be both problematic, in a hydrologic sense, and destructive to local interests and commerce in the Socorro–Sierra region, the Middle Rio Grande valley, and the state as a whole. Based on U.S. Department of Agriculture statistics for 2002, the market value of agricultural products associated with 12,500 acres of irrigated cropland in Socorro County is estimated at $17.2 million. It goes without saying that the loss of half of the irrigable farmland remaining in the county would precipitate economic and environmental doom for the region, particularly if the connected water moves with it. Loss of irrigated agriculture of the magnitude proposed would reverberate throughout local retail, commercial, and ranching businesses in the

entire Middle Rio Grande valley. The sale and transfer of an agricultural water right currently precipitates either the abandonment of irrigated land or continued irrigation through a water bank. When abandonment occurs on the floodplain, the land eventually reverts to water-consuming wild vegetation, while unregulated water banking leads to a doubling of actual water use. Both courses of action fail to achieve the intended hydrologic response of reducing the budget deficit, and could well wreak profound environmental, economic, and cultural damage. This alarming vision prompted a public welfare statement in the Socorro–Sierra regional water plan encouraging retention of agricultural water rights in the region, and caused the Middle Rio Grande plan to be met with apprehension and outrage by water planning representatives, decision makers, and residents in Socorro and Sierra Counties. The strategy where one jurisdiction tries to achieve water solvency at the expense of a neighbor is generally unpalatable and strictly prohibited in the Interstate Stream Commission's regional water planning guidance. In the final analysis, what does the state of New Mexico do when the Middle Rio Grande region has garnered the entire valley's water yet continues to demand more?

PATHWAYS TO CONFLICT RESOLUTION IN THE MIDDLE RIO GRANDE VALLEY

Substantial conflicts exist between the Middle Rio Grande valley regional water plans, yet the plans themselves and planning forums hold potential solutions. There is no single solution for resolving water and land management issues in the Middle Rio Grande valley, but the following list of remedies could provide benefits:

Public Welfare Statements—State statute requires consideration of public welfare in water rights administration. A number of regions, including those in the Middle Rio Grande valley, have developed public welfare statements, either within regional water plans, comprehensive plans, or county ordinances. Regional public welfare statements were envisioned by the 1986 investigative team and should be considered by the state engineer where water rights transfers may prove detrimental to a region and/or fail to promote hydrologic balance within the basin.

Administrative Solutions—A number of administrative solutions are available to the state engineer to improve water efficiency in the Middle Rio Grande valley: implement active water management in the Middle Rio Grande Conservancy District, declare critical management areas, meter on-farm or ditch diversions, meter domestic and other wells, and require compliance with maximum water conservation standards for all users—urban, rural, and agricultural.

Eliminate Water Management Conflicts within Middle Rio Grande Conservancy District—Two competing water authorities, the state engineer and the Middle Rio Grande Conservancy District, both claim control over management of water within the Middle Rio Grande valley. This competitive approach needs to be resolved so that both water delivery to priority farmers and the state's compact obligations are met.

Agricultural Efficiency and Innovative Cropland Management—Protection of agricultural land for future food production requires that new methods of managing agricultural land to keep a maximum area productive and economically competitive while minimizing water application be developed and applied. For example:

- Spread a water right over a larger area, fallow larger portions of irrigated plots in rotation, and transfer a portion of the right, keeping agricultural lands whole and productive.
- Continue to improve efficiency of water conveyance and on-farm application.
- Increase crop yields and incorporate more high-cash crops in rotation.
- Prevent abandonment of irrigated lands and reversion to invasive water-using vegetation by requiring a portion of any transferable right to remain attached to the land.

Manage Water Markets—Aggressive, open water-transfer markets that currently operate in New Mexico do not adequately balance the statutory mandates of private property right, conservation, and public welfare. There is understandable support for the notion that open markets should be allowed to operate aggressively to facilitate water transfers from agricultural to urban use as a means to accommodate growth and achieve hydrologic balance. However, third party impacts, including adverse effects on rural communities and the environment, should be taken into

account, and alternatives that avoid such impacts should be favored. This goal can be advanced through development of criteria that guide water transfers and consider region-of-origin protection and third-party interests.

Conflict Resolution and Collaborative Planning— Pursue resolution of regional and user conflicts through collaborative problem-solving forums. Examples include:

- The Upstream-Downstream Project works toward resolution of regional water conflicts in the Middle Rio Grande valley. The project was conceived and implemented by New Mexico Water Dialogue in 2006 with funds from the McCune Foundation and technical assistance from the Interstate Stream Commission and the Utton Transboundary Resources Center at the University of New Mexico. The project combines small work sessions for regional and local decision makers, support from a gallery of water specialists, and focused problem solving by a technical steering committee to resolve water-use conflicts in the Middle Rio Grande valley and identify fair and balanced solutions.
- The State Water Plan/Regional Water Plan Ad-Hoc Committee, appointed by the Interstate Stream Commission in summer 2003, develops recommendations for resolving differences between the State Water Plan and regional water plans and collaborates on strategies for plan implementation. Three topics addressed have been watershed management, implementing infrastructure needs, and water rights transfer policy.

IMPLEMENTATION OF STATE AND REGIONAL WATER PLANS

By addressing conflicts at a local, grass-roots level through regional water planning and collaborative problem solving, the interregional conflicts predicted by the 1986 study team can be mitigated, resolved, or altogether avoided. Regional planning provides a local perspective on public welfare and ensures that local needs are met, now and in the future. Without local input, any solutions or strategies implemented will be met with antagonism rather than acceptance. The 2003 State Water Plan provides a very clear policy statement promoting the role of regions in forging a water policy that accommodates and protects the diversity of New Mexico's communities and regions, and mandates that the state shall defer to regional guidance. What is lacking now is implementation. Local governments must step up to the plate and take the lead to ensure that regional plans are updated and implemented so that local water security is maintained. The state, through its various agencies, must continue to support and adequately fund update and implementation of both the state and regional plans. We can not afford to stop the process now.

Suggested Reading

State Appropriation of Unappropriated Groundwater: A Strategy for Insuring New Mexico a Water Future. WRRI Report No. 200, New Mexico Water Resources Research Institute and University of New Mexico Law School, 1986.

Water Needs and Strategies for a Sustainable Future. Western Governor's Association, 2006.

Water—Things to Do Now, and Do Better

Frank Titus

I pose a seemingly simple question here: What should we be doing to manage water affairs in the Rio Grande valley (and throughout New Mexico, for that matter) that we are not doing? I ask this penetrating question with some trepidation, because it is enormously complex. The potential number of thoughtful responses is huge, but I offer here a very short list of activities I suggest be elevated immediately to very high priority within the Office of the State Engineer and by the New Mexico State Legislature. If this means delaying other programs, so be it. I list below three specific proposals. Raising the emphasis on these activities is intended to advance our water welfare now, but more importantly to prepare a favorable environment for other more specific changes and improvements, some large, some small, that must subsequently be considered. I follow these proposals with a list of specific actions that would modernize our approach to water management in New Mexico.

1) Bring water rights records up to date in the WATERS database. No task in the Office of the State Engineer (OSE) is more important than compiling and maintaining a set of accurate records as the basis for water rights within the state. Years back the office began to copy its legal records into a computer-based file that would be available on the Internet. This electronic database is called the Water Administration Technical Engineering Resource System, or WATERS. Though current water rights transactions are said to be appearing on WATERS at a measured pace, the comprehensive compilation is far from complete and far from current.

Within this proposed state-wide task, the records for the Rio Grande and its ground water basins must top the priority list. Along this, our greatest river, transfers from surface water to ground water, movement of rights upstream, water-banking claims, and other legal changes are occurring at an accelerating pace. Water rights marketing, solicitations, speculation, and consulting activities (technical, legal, and otherwise) are ever expanding. The validity, legality, and orderliness of all of these depend on accurate and available public records. That is what WATERS was intended to be. Without these records, many water-transfer activities begin to look like a set of shell games. The lack of availability to the public of basic water rights data is unacceptable.

What seems to have happened is that the effort to build WATERS became large enough that the agency has not been able to staff it while carrying on its day-to-day functions. I received a comment many months ago from a staff member of OSE that until adjudication is undertaken on the Middle Rio Grande, the high level of effort needed to build WATERS cannot be sustained. To me this argument is backward: Adjudication cannot be accomplished without the records being in order and available. Such orderliness is a necessary precondition for preparing the myriad individual cases that will comprise the ground work, the negotiations, and the litigation of water rights adjudication.

Water rights trading in the marketplace should not be planned, accomplished, or recorded without accurate, verifiable historical backgrounds for every trade. Without WATERS, neither citizens nor professionals can check their own or their clients' water rights records. An up-to-date WATERS database would also help specialists in the OSE do their jobs. The complexities created by inaccurate or unavailable records extend well beyond those already cited. For instance:

- Many state engineer permits to pump ground water in the past were based on promises to retire surface water rights when pumping began to diminish river flows. Such "dedications" are of questionable legality; they constitute large, poorly defined water rights commitments.
- Water transfer records that affect the Middle Rio Grande Conservancy District, municipalities, counties, and other political entities are not listed in any repository other than WATERS, hence they cannot be publicly checked, audited, or used.
- Double dipping—the practice wherein transferors of surface rights continue to use water after it is transferred—is increasingly common under current administration, and it cannot be controlled or even reliably recognized without complete records.

- OSE evaluates and rules on current water rights transactions one at a time; without WATERS it has no apparent way to access a cumulative set of records for an entire basin.

2) Assure that Middle Rio Grande Conservancy District water deliveries meet priority and other dictates of state water law. The Middle Rio Grande Conservancy District (MRGCD) was created under state law in the early 1920s to reclaim water-logged farmland, provide flood protection in the middle valley, and consolidate the irrigation delivery system in the river reach from Cochiti Dam to Bosque del Apache National Wildlife Refuge. The district is generally bounded on the valley sides by the highline irrigation canals. The district obtained substantial financial assistance in its early years from federal agencies, principally the U.S. Bureau of Reclamation. MRGCD operates with considerably more autonomy than most governmental agencies and claims full authority over water management activities in the Middle Rio Grande valley.

MRGCD is the giant among water agencies in the Middle Rio Grande valley. It presides over water delivery to farming operations that result in about 22 percent of all water depletions in this reach of the valley. The conservancy district's basis for water rights claims is a 1931 OSE permit to change the points of diversion for some 132,000 acres-worth of surface irrigation water from the Rio Grande, including 8,847 acres of Pueblo lands with reserved rights, 80,785 acres of perfected agricultural water rights, and 42,482 acres of non-appurtenant junior rights claimed by the district as a result of salvage through its drainage system. Historically, the maximum non-Indian acreage under irrigation at one time on the Middle Rio Grande floodplain may have been more than 60,000 acres. This marked difference between the amount of non-Indian land ever irrigated and the district's claim of more than 123,000 acres of water rights should trigger careful legal analysis of the discrepancy. This area was traditionally irrigated by 70 or more historic acequias that were subsumed by the water delivery system of the MRGCD. Now, nearly 90 years after its formation, the district's claims to water have never been legally defined nor subjected to the normal constraints of beneficial use. The Office of the State Engineer has repeatedly demanded that MRGCD support its claims by submitting formal documentation for Proof of Beneficial Use. To date the district has not complied, though it may now be nearing completion of such a document.

Another issue that water rights owners within the district should demand be explored legally is whether pre-1907 rights appurtenant to multiple irrigated farms can be accumulated and claimed by MRGCD under some unique form of ownership. Such a claim should raise several issues, including at least (a) whether such landowners have thereby lost their priority positions for water delivery; (b) whether the district can lease or sell water outside of its boundaries when the delivery to any of these farms is short of the vested water right; and (c) whether these conditions are such that no pre-1907 right holder can, as an individual, sell his right outside of the district.

Under its broad responsibilities and power, the district has grown into a mighty but little understood, sometimes impenetrable, agency. It assesses all landowners within its boundaries, not just farmers, and it publicly reports very little of its operational procedures. It appears that only a very small minority of its taxable constituents attempt to understand its operations or decision processes.

In recent years, with the growth of municipal and related demands for water, the sale and transfer of individually owned pre-1907 water rights to non-irrigation purposes has increased. There are clear signs of two common effects from such water rights sales. The first is that MRGCD record keeping, especially records of the "move-from" lands, may not even exist; if it does exist, it is not transparent. The second is that after water rights sales, lands often continue to be supplied with water, through the drilling of domestic wells for subsequently built homes, or by the district, which for a price continues to supply irrigation water from a hypothetical bank of "junior" permitted rights. Such "double dipping" is patently wrong, irrespective of any arguments over legality, and hydrologically unsound in an over-appropriated basin.

The conservancy district has shown little interest in determining how much acreage and which farms have pre-1907 water rights. Furthermore, it has stated a preference for a "parity" (or shared-shortage) philosophy of water management rather than the state's statutory concept of priority of ownership. For MRGCD, non-priority management is advantageous, and certainly simpler than priority management. From the perspective of irrigators with older water rights, however, that simplicity will come at high cost: Their farms could receive little or no water during shortages, whereas, under a priority system, they would be at the head of the line.

It is apparent today that MRGCD's long-term aims are no longer geared solely to serving the farming community. Rather, they now suggest interest in the

increased power of being the regional water provider, based on the ability to control delivery to a very large block of water rights. This inevitably will dilute the power of the farming community. In fact, it already is doing so; the district's operational decisions seem dominated by moves to position itself as the major water supplier to municipalities. The water rights that are its capital are all based originally on individual ownership. By claiming that such water rights have somehow reverted to the MRGCD, an immense block of "capital" is created to meet the increasing demands of municipalities. If the district can develop a water-banking system that operates to its advantage, any water rights it claims need never be lost or sold. Rather, they can be leased to municipal governments, thus assuring perpetual dominance over regional water resources.

One should expect that MRGCD, being a water agency formed under state law, would support the Interstate Stream Commission (ISC) in its annual need to send a specified volume of water downstream. Compliance with the Rio Grande Compact is by far the most aggravating and potentially costly problem that New Mexico faces in its water affairs. However, MRGCD's operations and goals probably further threaten the state's basic ability to continue meeting its compact commitments on this river. The state engineer is the best (and likely the only) authority that can solve this problem—by assuring that the district plays by the same water rules as everyone else, and that individual water rights are not assumed summarily to have become the property of the regional water delivery agency.

It must be recognized that the problems of expansive water rights claims by MRGCD are ultimately unsolvable without adjudication. We must move with dispatch toward this legal resolution. Nevertheless, while awaiting adjudication, the district cannot be permitted to continually expand its wet-water use. Once expanded, trying to force contraction will be legally more difficult and doubly painful. Remember, this argument is being played out in an environment already conclusively shown to be short of water for compact delivery.

3) Create formal accounting, reporting, and operating rules for water banks. Formal, secure, well-understood procedures for water banking do not exist in New Mexico. Sale, with permanent transfer of rights, is currently the only structured way to augment water use in one part of a water basin with rights from another part. Such rigidity severely limits whatever beneficial role the marketplace might provide were water availability allowed to adjust to temporal and spacial variations in demand and supply in a given basin. What currently exists is an unorganized mess of "rules" invented individually by entrepreneurs, and private and public would-be water banks. There is little in the present "system" to instill confidence that accurate, auditable record keeping is part of today's water banking, or that protections exist for lessor and lessee, or even that transactions are backed by valid water rights.

I propose formalizing water-banking procedures. Defining such procedures requires creation of two new types of rules: rules to establish operating and reporting procedures for water banks themselves, whether the water banks be commercial entities or government agencies, and basin-specific rules to establish what arrangements are and are not permitted within each individual water basin.

Water banks should be legally recognized and the rules under which they operate standardized by the state. The rules should guide record keeping, auditing, transparency, legal accountability, and procedural standardization. Water banking should have a degree of reliability and security reminiscent of money banking. Its operations should be simple and open. The legislature is the appropriate place for established rules governing water banks. These rules do not have to be complicated, but they do need to be explicit.

Basin-specific rules should have characteristics that reflect both a standard of performance throughout the state and the individual and unique needs of each basin. The staffs at OSE and ISC should cooperatively produce an interim set of rules, then invite detailed input from the public within each basin, including input from the formal public groups that produced relevant regional water plans. The OSE should be the responsible state agency, but if the various rules are well constructed, it should not have to involve itself in individual lease transactions.

Creation of detailed rules for water banks and the state's several water basins will require a significant effort. Interim rules could be expeditiously devised, preferably by small panels of experts, and the rules then tested during an interim period of one or two years. Here are a few water-banking concepts that might be considered in constructing a preliminary set of rules:

- Set limits on the distance upriver or downriver a lease could be transferred.
- Provide some form of area-of-origin protection that addresses third-party impacts.

- To be leasable, a water right should be on record within the OSE system and should be in the WATERS database (to use a pre-1907 right, for instance, it must have been declared).
- A water right should only be leased for up to two years before reverting to its original land base for two or more years (the intent is to disallow permanent leasing).
- Some percentage of the leased water should be tithed to support a specific ecosystem activity or benefit within the basin or area of origin.
- Accurate records must be rigidly required, record formats should be defined, and all leases should be published and transparent.
- The beneficial use for the leased water should be specified in the lease.
- Assure, through a formal tracking system, that water banking doesn't facilitate "double dipping."

Until formal rules are in place, the present systemless arena will continue to invite manipulation and will provide little protection for the rights of participants. This is especially true when the absence of rules is combined with failure of the OSE to provide access to fundamental water rights records. It is easy to anticipate in these circumstances that those most likely to be injured will be the small players, such as individuals and family farmers.

The immediate and equally pressing reason we should be moving to reestablish and simplify the internal order and consistency in water management, however, is the inevitability that change will be forced on us, if and when we cannot meet our Rio Grande Compact commitments. Today we are still free to discuss and devise our own fixes for the inefficiencies and inequities already recognized in the system. But if failure to meet the compact is the driving force, our flexibility goes down, and the ultimate costs go up.

THINGS ARE NOT WORKING WELL NOW AND SHOULD BE CHANGED

An impressive community of citizens has for more than a decade been expressing serious concerns about New Mexico's water future. This very knowledgeable community includes technical specialists on environmental and water affairs and many non-specialists who have learned a lot about environmental and community welfare. The voices of this community, especially those concerned with environmental sustainability, have been raised again and again in forums like the New Mexico First town halls, conferences of the Water Resources Research Institute (WRRI) and Middle Rio Grande Water Assembly, meetings of New Mexico Water Dialogue and the Public Interest Research Group (PIRG), and groups that wrote the regional water plans. Here, in no particular order, are some of the topics that have been discussed repeatedly in these forums and that need to be fixed:

- The State Water Plan must be made into an actual plan to explicitly control our water destiny, and it must be made implementable and enforceable.
- Comprehensive water budgets should be constructed by region. Regional negotiations are impossible without budgets that show instream flows, riparian use, aquifer storage, human uses, etc.
- Water rights priorities should apply to both surface and ground water, hence priority must be equally enforceable on both.
- Establish instream flow requirements. Rivers must explicitly be allowed to have water, and rivers' rights should fit formally into state water rights systems.
- Eminent domain over water rights should be limited. The public should discuss this, and public opinion should have major influence on final decisions.
- Try for a formal, state/tribal agreement on Indian water rights. This will help avoid individual tribal lawsuits, which likely would result in tribal inequities.
- Measure all diversions; require measurement and reporting of all water diversions of both ground and surface water.
- Change state statutes to lengthen the tenure of the state engineer and minimize political turnover. The long learning curve makes rapid turnover inefficient, and even a tough, effective, visionary administrator cannot survive pressure politics.
- Conservation that reduces depletions should be required of all water-use sectors; water saved should go to mitigating the basin deficit.

- Work toward a healthy bosque of native plant species; that means working toward removing exotics and optimizing the mix and density of native species.
- Rejuvenate the valley environment below Bosque del Apache National Wildlife Refuge. Put the river down onto its floodplain and replace exotic phreatophytes. If farming would use less water than wild phreatophytes, find a way to transition to farms, and a way to water them.
- Restrict the extent of Elephant Butte Reservoir so that it does not extend above the Narrows, in order to reduce evaporative loss. Negotiate for replacement storage upstream (e.g., at Abiquiu); offer to share saved water with the Elephant Butte Irrigation District and Texas.
- Establish a research farm on the floor of Elephant Butte Upper Basin to study low-water-use crops, evapotranspiration suppression, and related water-saving technologies. If low-water-use farming is practical, devise cheap leases and water grants or other innovations. New Mexico State University has received substantial federal funding for decades as our Land Grant College and should lead this effort.
- Encourage and support basic and applied research in the varied fields that intersect in the general realm of hydrogeology; to continue improving system management, we require ever-improving levels of technical understanding and ever-increasing data.
- Strengthen levees to a standard level of protection. This is a no-brainer wherever levees are essential for protecting human populations. Here's an imaginative yet pragmatic idea championed by a growing number of ecosystem thinkers: In conjunction with the levee system, create bleed-off areas outside the levees into which floodwaters could be diverted to help take the crest off of high flows, while simultaneously replenishing the aquifer, nurturing fish habitat, and supporting a healthy mosaic of native bosque. The aim would be to re-create some of the beneficial effects of natural system dynamics rather than sticking to old, unimaginative methods of floodwater control. Seek ways to make this permissible under the Rio Grande Compact.

Now, let's get moving. Every thinking New Mexican knows we have water management problems that we don't address. I doubt, however, that most citizens realize the several astonishing discrepancies between reality and management practice that our water leaders have been handed from the past but continue themselves to condone. The agonizing loss of our argument before the U.S. Supreme Court over the Pecos River Compact nearly twenty years ago has required stressfully negotiated adjustments in the Pecos River valley, is costing the state a lot of money, and should point inescapably to the much more stressful and immensely more costly problems we ultimately will face on the Rio Grande. The state engineer's Active Water Resource Management program provides an essential first step toward management modernization. The recommendations in this paper offer another step. Let's hope that the Office of the State Engineer and the state legislature cooperatively elect to use these as a springboard toward hydrologic reality in water management, and toward greater justice for our citizens.

The Unintended Consequences of Water Conservation

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Although the phrase *water conservation* means different things to different people, it generally implies an act or policy that will result in additional water for other uses. Conservation of water is widely accepted as good, whereas wasting (or not conserving) water is bad. However, how conservation outcomes are assessed depends upon unit of analysis or point of view, and there is often a discrepancy between the physical reality of the hydrologic system and both public and agency perceptions of water issues. Many people are incorrectly convinced that certain activities (such as increasing agricultural irrigation efficiency) will inevitably result in additional water for other uses. Public policies have been implemented and billions of dollars in public and private investments spent in the name of conserving water in irrigated agriculture. Unfortunately, many of these investments have not made additional water available to new users. In some cases they may result in less water for other users in the basin.

Water conservation is a cultural and political icon that is considered by many to be beyond reproach. In today's highly charged water resource debates, skepticism about water conservation is tantamount to an assault on religious sanctities. Quite often, water conservation *intentions* carry more weight than water conservation *evidence* in policy debates, funding opportunities, and newspaper headlines. This paper addresses the discrepancy between intentions and evidence, as well as the unintended consequences of water conservation, particularly as related to irrigated agriculture in New Mexico.

WATER DEPLETION AND IRRIGATION

Evapotranspiration from the watershed's surface is the true depletion or loss of water from a hydrologic basin. The principle is based on the Theory of the Conservation of Mass; water diverted (i.e., removed from its natural course or physical location through a canal, pipe, or other conduit) and applied in irrigation in excess of evapotranspiration is not lost, because much of it flows back into the basin from which it was withdrawn. This water eventually becomes available to other users at other times in other locations, although a fraction of diverted water in a basin may be unavailable to other users because of incidental losses such as evaporation from open water surfaces and moist soil, non-beneficial evapotranspiration from riparian vegetation, and contamination; because the water returns to the basin too late or too far away to be of practical use; or because the water flows into an irretrievable sink (such as the ocean) or an area beyond reach (such as another state or country).

Irrigated agriculture accounted for 76 percent of total water withdrawals in New Mexico in 2000. It is commonly assumed that reducing water depletion through increased irrigation efficiency will always result in extra water, and agriculture is under pressure to change. However, hydrologic systems are not zero-sum entities where one user's diversion is always another user's loss. The hydrologic reality is that one user's water "inefficiency" often serves as the source of another user's water supply. Examples illustrating this situation are presented below.

DRIP IRRIGATION

For several years farmers have faced a steady barrage of recommendations to use sophisticated irrigation technology (rather than traditional surface irrigation methods) and thus increase on-farm irrigation efficiency. Sprinkler irrigation was an early recommended technology; now drip irrigation is commonly recommended. Drip irrigation allows for precise application of water into plants' root zones, with very little deep percolation loss. There is generally a linear relationship between evapotranspiration and yield over a wide range of crops and water applications. Consequently, irrigation technologies that apply water at optimal times and locations in plant root zones increase crop consumptive use of water and crop yield even as irrigation efficiency increases. For example, because subsurface drip irrigation of alfalfa does not have to be suspended during harvest, the consumptive use of drip-irrigated alfalfa is higher than surface-irrigated alfalfa, where the crop usually experiences significant water stress when harvesting machinery is in the fields.

Alfalfa is grown throughout New Mexico's irrigated areas. The evapotranspiration requirement for an acre of alfalfa is typically three acre-feet of water. This level

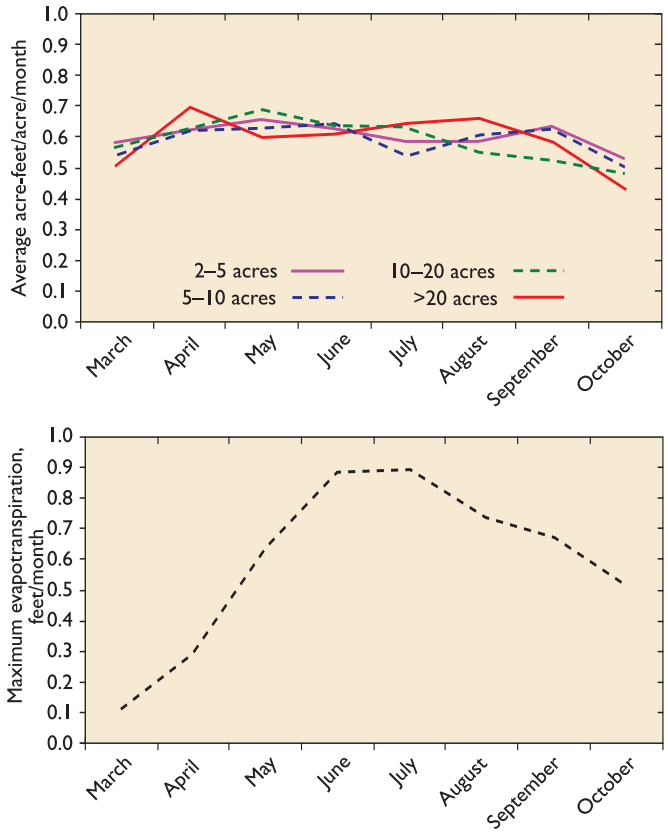
of consumptive use in the desert Southwest is an example of deficit irrigation, where a crop is irrigated with less water than what would allow the crop to reach its potential yield with full irrigation. Assuming an on-farm irrigation efficiency of 75 percent, the farmer would need to apply four acre-feet per acre of water. Thus, three acre-feet per acre are consumed by the plant, and one acre-foot per acre returns to ground water through deep percolation. This level of evapotranspiration will result in approximately five tons of alfalfa per acre. If the farmer adopts drip irrigation, consumptive use can easily increase to five acre-feet per acre (or more), with potential yields of eight tons per acre (or more). An on-farm irrigation efficiency of 75 percent is actually low by the standards of commercial farms in southern New Mexico, where these efficiencies have been found to be as high as 93 percent (pecans and alfalfa) and 95 percent (cotton) as a result of deficit irrigation practices.

Water "waste" through deep percolation or runoff will be reduced through drip technology, but more water will be consumed by the plant. The individual farmer who uses the technology will have increased yield and income per unit of land. From the farmer's perspective, the new water-conserving technology has had positive effects. However, basin-level consumptive use increased. This does not mean that drip irrigation will always result in increased depletion in every irrigated region. For example, farmers in New Mexico's Las Uvas Valley pump water from a deep aquifer to produce alfalfa with an irrigation efficiency of about 40 percent due to the area's sandy soils. Water lost to deep percolation ends up in a saline clay formation and is not currently recoverable. In this case, drip irrigation would result in saving applied water even though the depletion impact is about the same. Generally, the link between increased irrigation efficiency and reduced return flow is most applicable to shallow, stream-connected aquifers.

IRRIGATION SCHEDULING

Irrigation scheduling involves applying water to growing plants in accordance with their consumptive use needs. Frequency and duration of scheduled irrigations are based on environmental conditions, plant growth stage, and predicted evapotranspiration. Successful scheduling requires knowledge of plant water needs, and an irrigation system that is flexible enough to respond to changing needs throughout the growing season.

Proper irrigation scheduling can significantly increase yields and crop quality. For example, during the nut-filling period in southern New Mexico pecan production (late August to early September), a delay in irrigation can result in large yield reductions. Irrigation water applied to pecans and many other crops does not have the same yield and quality



Application of irrigation water to pecans in southern New Mexico by farm size (top panel), and maximum monthly evapotranspiration, in feet per month (bottom panel).

impacts throughout the growing season. With correct irrigation scheduling, total yield and total water consumption by the crop can both increase. If a farmer's goal is to produce a higher level of economic return from a unit of consumptive use, then optimally scheduling irrigations to match crop evapotranspiration is a very desirable practice—but one that may result in increased total evapotranspiration for the basin.

There are approximately 20,000 acres of pecans in southern New Mexico. A recent study of irrigation practices on 340 pecan farms in the region showed that farmers (over a wide range of orchard sizes) were over-applying water during periods of low consumptive demand and under-applying during the critical period of high consumptive demand. This misiming

of water applications results in yield reductions and low water use efficiency (i.e., yield return per unit of water consumptively used). The figure on the previous page indicates that the average application of water is fairly consistent with average crop water needs over the entire growing season, with over-application balanced by under-application. However, irrigation is a means to an end, and pecan yields are compromised by the irrigation patterns shown.

Like efficiency-enhancing drip technology, optimal irrigation scheduling can result in increased consumptive use and subsequent reductions in water available to downstream and future users because of the net reduction in water supplies. The surface water shown as over-applied in the spring months in this figure returns to the hydrologic system, and is no longer available to the trees to which it was applied. The water, which eventually reenters the aquifer or the river, (1) contributes to surface water supplies later in the growing season, miles (and possibly a state or nation) away from where it was originally applied, (2) is likely degraded in quality as a result of salt leaching, and (3) contributes to ground water recharge. Widespread adoption of accurate irrigation scheduling could increase on-farm water use efficiency, yields, and pecan growers' incomes; however, it would also reduce the basin's downstream flows (whatever quality they might be), reduce ground water recharge, and contribute to salt accumulation.

CANAL LINING

Canal lining is often considered to be a "magic bullet" for reducing water "losses." However, canal lining can result in negative water conservation and is unlikely to produce more water for new users. Good examples are provided by the acequia systems of northern New Mexico and the return flow system of the Middle Rio Grande Conservancy District. These systems are essentially man-made Rio Grande tributaries, as they contribute to return flows in the main river channel. In such cases, lining a canal will make farm diversion more efficient but will result in extra depletion if the diverted water is transformed into higher yields. The consequence of this can be reduced in-stream flow, lower water quality, reduced return flows for downstream water users, and overall increased net depletion in the river basin.

The belief that canal lining will conserve water is international in scope. Millions of dollars are spent annually in the United States and other countries to line canals for the purpose of increasing water supplies for urban, industrial, and agricultural users. Canal lining projects are likely to increase gross economic returns for existing farmers or the irrigation district in the affected area. Thus, canal lining may be valuable as a means to increase farm household and district revenues, but it may have no capacity to increase water available for other users. Furthermore, canal lining can negatively impact natural vegetation and wildlife because of seepage reduction.

WHAT IS TRUE WATER CONSERVATION?

Water conservation is basically sound and appropriate water management, but how that translates into specific definitions and actions depends primarily on individual objectives. For a commercial farmer, achieving higher yields through efficient water application is sound water management. For a downstream farmer, water flowing through a drain system as a result of an upstream farmer's over-application is sound water management because it created his water supply. For an advocate of the environment, greater in-stream flows are sound water management, even though those in-stream flows may be the result of very "sloppy" upstream water management. For a growing community with ever-greater demands for recreational opportunities, using water to create a high-quality golf course is sound water management. Dozens more specific examples of sound water management could be given here. Regardless of the number of examples, they all imply that there is and will be little widespread agreement as to what our water conservation objectives should be.

In a water deficit environment such as New Mexico, the technological magic bullets often proposed for agricultural water conservation may have no positive net effect and may in fact increase total basin-level depletions. This fact is rarely advertised by technology vendors and contractors, or by those who advocate the use of public funds to support these technology investments. Adoption of the technologies discussed above is likely to increase depletions and result in less water for other users in a basin. New Mexico's compliance with downstream interstate compact delivery requirements have been and will be compromised by the adoption of such technologies.

If New Mexico intends to get serious about agricultural water conservation in the future, then one of the first steps that should be taken is accurate accounting of basin-wide water use. Accurate accounting would likely release water for new users. Lack of large-scale accounting and administration may be cheap for water

managers, but it contributes to an informal water resource management system that relies on ignorance and inadequately defined property rights for its perpetuation. Unfortunately, more data, information, knowledge, and understanding of the water resource are not considered good things by many members of the water resource community. Ignorance resulting from the lack of rigorous water measurement and accounting preserves and protects the status quo, and encourages opportunistic scofflaw behavior by many water users.

Increasing water resource accountability would be a dramatic change in the status quo and would require large increases in data and information about water use. Increased accountability would be a major culture change, and quite different from the popular technological Band-Aid approach (e.g., drip irrigation, irrigation scheduling, or canal lining) to agricultural water "conservation." Of course, agricultural consumptive use in New Mexico can be significantly reduced, and potentially huge volumes of water can be made available to other users, if agriculture itself is reduced in size and land is converted to non-agricultural uses. That change would be dramatic as well and appears to be well underway in parts of the state. However, in New Mexico's current water deficit environment, eliminating water consumption by one user (i.e., agriculture) does not necessarily mean water will be released automatically to other users. Natural vegetation is also a deficit water user, and additional water may simply be consumed by natural vegetation before it becomes available to other potential users.

Suggested Reading

Irrigation Practices vs. Farm Size: Data from the Elephant Butte Irrigation District by R. Skaggs and Z. Samani. Agricultural Experiment Station and Cooperative Extension Service Water Task Force Report #4, New Mexico State University, 2005.

Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000 by B. C. Wilson, A. A. Lucero, J. T. Romero, and P. J. Romero. New Mexico Office of the State Engineer Technical Report 51, 2003.

Balancing the Budget: Options for the Middle Rio Grande's Future

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A water budget analysis for the Middle Rio Grande region[1] including both surface water and ground water indicates that, on average, and assuming a wide range of historic climatic conditions, the sum of water used plus New Mexico's Rio Grande Compact delivery obligation exceeds water inflow. This analysis indicates that under present development conditions and without mitigating actions, the region will experience an average annual surface water shortfall of approximately 40,000 acre-feet per year. At present, ground water pumping, which provides the water supply of most cities, imparts an additional annual deficit of 71,000 acre-feet to aquifers; this is the amount of ground water pumping that has not yet impacted the river. Through recent favorable circumstances and management actions, New Mexico maintains compliance with the Rio Grande Compact. Nevertheless, many stakeholders in the Middle Rio Grande understand that the existing pattern of water supply and water use is not sustainable. Meeting existing demand and maintaining compact compliance will become more difficult as the lagged impacts of ground water pumping on the river continue to grow. Further challenging the water planning process are increased water uses associated with projected population increases and maintaining endangered species flows and habitat.

Recent water budget modeling underscores what has been assumed by water management for decades: The basin is "fully appropriated." In fact, the water budget studies suggest that on average, the basin is over-appropriated. New water uses impacting stream flows can only be supported by the cessation of existing uses such that the overall consumptive use of stream flow does not increase, or new water sources must be developed.

WATER SHORTAGE: AGAIN!

Over a period of many centuries, water users have periodically faced the dilemma of water shortage in the Middle Rio Grande region. A casual reader of historic and archaeological accounts can observe the following historic responses to water shortage:

- ***Management and community-based shortage sharing***—Local communities develop shortage-sharing programs, recognizing water as a community resource, implementing management, and reducing usage as necessary for the common good
- ***Enhanced conservation***—Shortage motivates conservation measures that stretch the available supply
- ***Supply augmentation***—New supplies are developed to support economic development
- ***Adversarial confrontation***—When all else fails

These responses to water shortage are age-old. Water management and shortage sharing founded on community property values are a cornerstone of Rio Grande water administration and continue to be practiced by acequia communities. Although many trace acequia customs to practices of medieval Spain and Moorish influence, one may also find examples of this type of management in Pre-Columbian cultures throughout the Americas, including the pueblos of the Rio Grande. There is logic to this precedent, as its widespread use attests. Similarly, enhanced conservation has been practiced for centuries. Check dams on intermittent waterways were built to hold back water for small plots; lands were terraced to optimize the use of available water; small canals were lined with rocks. Many such examples can be found in both Pre-Colombian and Hispanic acequia cultures, in addition to more contemporary conservation measures such as laser-leveling of irrigated fields. These practices conserved the water resource for use by water-based communities and were effective until either climate variations or population pressures stretched the systems too far. Often in such cases supplies were augmented. Along the Rio Grande, Hispanic colonists augmented supplies by constructing stream diversions that weren't necessary for smaller populations. Later, limits

[1]The term *Middle Rio Grande region* is used in this article to refer to the area generally between Otowi and Elephant Butte, and is not to be confused with the Middle Rio Grande Planning Region, which occupies a subregion within the Albuquerque Basin of the Middle Rio Grande region.

on water availability through diversion alone spawned ambitious water storage projects: from Elephant Butte Reservoir in the early 1900s to Heron Reservoir and the San Juan–Chama Project in the 1960s. Remaining limitations motivated large-scale ground water pumping that continues today. For centuries conservation and management of water supplies for the common good have delayed or minimized impacts of shortage, and cycles of shortage have been answered with the development of "new" water sources. Peppered between have been instances of conflict, including the occasional violent confrontation. And, in the past century, priority administration has been applied in some Western states to allocate supply that falls short of demand.

These mechanisms for handling water shortage remain available today. The challenge for regional water planners and decision makers is to decide how to apply the first three mechanisms (management, conservation, or augmentation) to balance the water budget and how to avoid various renditions of the fourth (adversarial confrontation), perhaps in the guise of a court battle or imposition of federal watermaster.

SOLVING THE PROBLEM? THE NEXT FORTY YEARS

State and regional water planning entities recognize that challenges are imminent in the Middle Rio Grande region. We have forestalled the day of reckoning by careful storage of extra water in wetter years, effective flood routing, improved conservation efforts, and through expansion of water supply from ground water pumping. However, these measures are insufficient to avoid water budget deficits at the present level of development, and, clearly, will not be adequate under conditions of increased growth.

To identify methods for balancing the water budget, the regional planning entities largely situated in the Middle Rio Grande basin, including the Jemez y Sangre Planning Region, the Middle Rio Grande Planning Region, and the Socorro–Sierra Water Planning Region, have recently developed regional water plans. The plans include:

- Improved conservation, including urban and agricultural elements
- Reduction of water use from open water and riparian vegetation
- Transfer of water from agricultural to urban uses
- Acquisition of new water supplies, i.e., desalinated water from distant basins or cloud seeding

However, in significant respects, the plans are inconsistent. Considering regional perspectives on agricultural lands:

- The Jemez y Sangre Planning Region would augment their water supply through the retirement of irrigated acreage (amounts unspecified), including lands above Otowi and lands within the Middle Rio Grande Conservancy District below Otowi;
- The Middle Rio Grande Planning Region would augment their water supply through the retirement of 7,500 acres of irrigated acreage in the Socorro–Sierra Water Planning Region and 11,000 irrigated non-pueblo acres within their own region;
- The Socorro–Sierra Water Planning Region, on the other hand, identifies maintenance of the existing agricultural economy and retention of water rights within the region as key regional goals.

Both the Jemez y Sangre Planning Region and the Middle Rio Grande Planning Region look beyond their boundaries for agricultural lands to retire; however, none of the three planning regions welcome the retirement of agricultural lands within their boundaries to serve the urban needs of others.

Considering riparian vegetation:

- The Middle Rio Grande Planning Region would augment their water supply through the reduction of riparian vegetative water use within the Socorro–Sierra Water Planning Region by 17,500 acre-feet per year (they also propose reducing riparian vegetative water use within their own region by a similar amount);
- The Socorro–Sierra Water Planning Region would augment their water supply through reduction of riparian vegetative water use within their region in an amount within the range of 4,000 to 20,000 acre-feet per year.

The elimination of evapotranspiration from riparian vegetated lands is difficult and costly especially in areas where the depth to water is shallow. Successful projects must replace non-native vegetation with lower water using plants, and they must avoid re-colonization and soil evaporation from low-lying valley

lands. Both the Middle Rio Grande Planning Region and the Socorro–Sierra Water Planning Region target an amount of land where these projects might be feasible; however, the combined feasibility is questionable. Taking both plans together, restoration of 54,000 acres of riparian vegetation between Cochiti and Elephant Butte is proposed.

Beyond the inconsistency among regional plans for agricultural land retirement, and the questionable feasibility of riparian restoration goals, are challenges of other plan alternatives:

- *Importation of 22,500 acre-feet per year of desalinated water by the Middle Rio Grande Planning Region.* The importation of desalinated water from the Tularosa and Estancia basins to augment supply is a concept not yet realized in the Middle Rio Grande basin. This alternative will bear significant energy costs along with environmental and legal issues.
- *Reduction of Elephant Butte Reservoir evaporation.* The Socorro–Sierra Water Planning Region proposes reducing water demand by 12,000 acre-feet per year through reduction of riparian vegetation in exposed reservoir bottom land. This alternative presents significant engineering and financial challenges.

Setting aside questions of feasibility, if one assumes that the alternatives identified by the regional water plans are implemented within the next forty years, what is the outcome? A water budget analysis has been applied to this question, making only minimal changes to the proposed alternatives to avoid patently inconsistent elements among regions. This analysis, described in the *Middle Rio Grande Water Supply Study, Phase 3*, indicates that under conditions of full implementation, in 2040 (with projected population increases) the surface water deficit is reduced from approximately 40,000 acre-feet per year to 7,000 acre-feet per year, and the ground water deficit is reduced from approximately 70,000 acre-feet per year to 40,000 acre-feet per year. Complete implementation still finds the Middle Rio Grande region in debt, albeit closer to a balancing point. However, in 2040 ground water depletions are again increasing, even with implementation of ambitious conservation and augmentation actions, and with the Albuquerque Drinking Water Project in place. The "solution" to today's shortage provides some relief but sets into motion actions that again place the Middle Rio Grande region onto an unsustainable course.

Most of the analyses described above have been conducted without significant pueblo participation. Pueblo water uses are unquantified and unadjudicated, yet are generally considered senior to non-pueblo uses. The potential for further development of pueblo water resources casts additional uncertainty on the disposition of available water supplies in the Middle Rio Grande region.

Further clouding projections of future supply are questions regarding climate change. Climate modeling predicts reduced water availability in the Southwest, even if precipitation rates remain constant, because of increased evapotranspiration rates due to increased temperature.

SCENARIOS AND ACTION PLANS FOR THE FUTURE

The Concrete Valley

Various names have been proposed for this scenario, for example, "Phoenix" or the "Los Angeles River." We fail to balance the budget, and large-scale ground water mining occurs. The Rio Grande becomes disconnected from the aquifer; river losses are high, and flows are difficult to maintain. Waterways for agricultural delivery must be concrete lined, perhaps piped. Water table conditions can not support a bosque, and only artificial silvery minnow habitat can be maitained. Large areas of the valley are paved, saving water previously used by riparian or agricultural vegetation, and we still manage to make our compact deliveries. (Under current state engineer administration, this is an unlikely, extreme scenario; nonetheless, it could occur by default with lax or ineffective administration.)

The Watermaster's Plan

We try to manage but somehow fail. A series of years pass with unfavorable inflow for meeting our compact obligation. An interstate court battle ensues, and the river is managed by a federal watermaster. Water management goals are defined by decree; incorporation of sub-regional or community-based management options is unwieldy and unlikely. (No action plan is necessary to achieve this scenario.)

The Preferred Scenario

This one is more difficult to describe. However, most stakeholders and planners have some vision of this in mind. They want a future Middle Rio Grande that looks like New Mexico. They acknowledge a

desire/need for some growth, though they want the valley to "remain green." They want preservation of environmental and cultural values. The existing state and regional water plans have initiated the process of defining a set of actions and compromises necessary to achieve the preferred scenario, but they are in their infancy. Immediate and sustained implementation of a coordinated action plan is needed for this scenario.

Key elements of the action plan will draw selectively from historic precedent. A few comments on the applicability of these precedents to balance the water budget in today's shortage cycle are noted:

1. Management and community-based shortage sharing—Shortage sharing is appropriate, and necessary, at some "community-based" level. Shortage sharing of limited water rights for a given use in a given area is reasonable, for example, within a municipality or within an irrigation district. The difficult exercise is defining the unit suitable for shortage sharing. Planning regions must ask if it is reasonable to shift the burden of their growth to another region, as such an expectation will likely defeat efforts to create coordinated and successful water plans.

Though some might argue that New Mexico's appropriation doctrine and established code of water law and regulation are antithetical to modern resource management, on the other hand, this water allocation system provides an excellent framework for handling water budget challenges. Appropriation doctrine provides use-limited rights to water with protection for established uses, and, as codified more recently, requires consideration of conservation and public welfare. These features are essential to the protection of existing resources and values in New Mexico. Further, New Mexico offers mechanisms for community-based governance where possible. The statutorial incorporation of acequia management customs, and more recently, the crafting of provisions for local management under Active Water Resource Management, for example, as is being drafted for the Lower Rio Grande basin, offer many advantages for community-based water management under shortage conditions. Further, Active Water Resource Management provides a mechanism for controlling water use when regional supply is insufficient. New Mexico benefits from a robust statutory and regulatory framework but struggles with inadequate funding to comprehensively apply the management mechanisms. Rapid adjudication of Middle Rio Grande water rights and strengthened enforcement of permitted conditions of approval (i.e., ensuring that retired lands stay dry) are essential for future management in the basin.

2. Enhanced conservation—Conservation involves using less water for a given use and is an important element of all water plans. However, from a basin-wide water supply standpoint, it is only a *reduction in consumptive use* that stretches the water supply. There are many conservation measures that reduce diversion needs but have no impact on consumptive use. In such cases, diversions and return flows are reduced, but the actual loss of water to the system, overall, remains the same. These measures, though useful from a water operations or environmental standpoint, don't address the problem of basin-wide water shortage. For example, the use of drip irrigation reduces the amount of water needed for diversion, but also reduces the amount of water returned via subsurface drainage to drains and back to the river. Aside from possible reductions of surface evaporation, there is no net water savings. Similarly, water-saving fixtures may save water in terms of inflow, but wastewater returns are similarly reduced. Implementation of such conservation measures won't yield the region-wide savings needed to balance the water budget.

There are conservation proponents who believe that the entity implementing conservation should be entitled to use the "saved" water as an incentive to conserve. This viewpoint is inconsistent with the appropriation doctrine, which provides for a reasonable quantity of water to satisfy a specific use. If the saved water only derives from reduced diversion and a reduced return flow, there is no "new" water to support expanded consumptive use. However, when conservation results in reduced consumptive use, for example, clearing water-consuming brush from ditch banks, the saved water reasonably belongs to the public. In the case of an over-appropriated basin such as the Middle Rio Grande, this type of savings in consumptive use is what is needed to balance the budget. Regional water planners must focus on identifying and implementing conservation measures that reduce consumptive use, and avoid expensive conservation measures that have no net impact on the water budget.

3. Supply augmentation—Supply augmentation becomes more difficult with each cycle of shortage. For centuries, water users in the Middle Rio Grande have looked for and found means of supply augmentation to solve shortage (diverting water from streams, pumping ground water, importing water from other river basins). These solutions increasingly come with unintended consequences, the most dramatic being the lagged impacts of ground water pumping that creates a debt for future generations. Prudent manage-

ment would suggest that new sources, if they exist, should be identified, tested, and developed before assuming that they will be available to satisfy future growth.

***4. Compromise*—**Departing from historic precedents, confrontation is replaced with compromise. For balancing the water budget, little "low hanging fruit" remains. Largely, tough choices involving trade-offs remain. Planning regions have initiated the process of identifying trade-offs but will need to follow through with implementation. Adjustments to accommodate changed conditions, including additional pueblo uses or climate-based supply reduction, will be required. Actions that can be accomplished within planning regions, without assumption that the resources of neighboring regions are available, are likely to be most successful. The State Water Plan will need to track and reconcile the regional goals and actions. Administration of water rights will require more capital and labor, as without careful monitoring and enforcement, solutions will be circumvented.

In summary, balancing of the water budget in the next forty years, particularly given projected growth rates and climate change impacts, is an ambitious proposal. Success in this endeavor will require focused design and implementation plans, inter-regional coordination, state leadership, political support, and capital outlay, beginning now.

Navigating the River of Our Future—The Rio Poco-Grande

William deBuys

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All elements of the southwestern landscape—deserts, prairies, woodlands, and forests—are much changed from their aboriginal condition, and they continue to change. Unfortunately, society's ability to recognize and adjust to those alterations invariably lags the changes themselves. We are slow to define the dimensions of change, slower to agree that it demands adaptation, and slowest of all in implementing needed adjustments, which are nearly always complex and difficult, requiring new political consensus and institutional change.

For a cautionary example of how badly our society has handled such challenges in the past, we need look no further than the story of the western range and the debacle of overgrazing that transformed it. As early as the 1870s, John Wesley Powell and others began advocating a system of leases to avert a continued tragedy of the commons on the rangelands of the public domain. But the on-going crisis produced little but argument for more than half a century. Between 1899 and 1925, eighteen bills to regulate grazing on the public domain were proposed in the US Senate; in roughly the same period the House entertained twenty-five such bills. All failed, largely because of fear that regulated leases—instead of wide-open winner-take-all competition—would enable big operators to squeeze out homesteaders. The effect of this stand-off was to assure the continued deterioration of a vital resource long after the resource was acknowledged to be in danger. Lack of action to abate this tragedy persisted until enactment in 1934 of the Taylor Grazing Act, which survived its crawl through Congress thanks to clouds of Dust Bowl dirt raining their proof of national ineptitude on the nation's capital. Even so, the problems of the western range were hardly cured.

The present overstocked, fuel-heavy condition of western forests is another sobering example of society's faltering ability to adapt to the environmental changes it engenders. In this case, decades of fire suppression have produced conditions that favor stand-changing fires of an intensity unprecedented in the natural history of the forests most affected. An increasing frequency of catastrophic fire has galvanized popular desire to address the problem, enough so to cause the ship of public policy to begin a long, slow turn. The pilot house of that ship, however, has proved to be a crowded and argumentative place, and agreement on the new course the ship should follow remains elusive.

The fate of southwestern rivers, like that of the region's forests and rangelands, is being shaped by society's response to the most fundamental problem affecting its relationship to the environment. This is the competition between the survival needs of complex ecosystems, on the one hand, and the task of providing natural resources for human use and essential services such as flood protection and waste disposal, on the other. We are linked in this task to our forebears. Previous generations worked with great resolution and energy to develop the resources of New Mexico and the Southwest. Our generation now faces the obligation to deal with the consequences of that development.

This, in a sense, is a leading theme of the history we are making today. Since 1492 most of the environmental history of North America has involved, literally and figuratively, the breaking of new ground. But as we encounter limits of supply (as with western water) and adverse consequences of past use (as with forest health), the history of the future will increasingly involve contending with the consequences of what was broken. For the sake of prosperity, if not survival, we and our neighbors throughout the world have entered an age of obligatory adjustment and repair. This is one of the fundamental tasks of our time. It's not what our fathers and mothers, grandfathers and grandmothers undertook, but it is our mission, and history will judge us on how well we accomplish it.

These themes of alteration, competition, and both the difficulty and necessity of repair dominate the history of the Middle Rio Grande. If we were to look at a map of the alluvial plain of the river as it existed in, say, 1900, and if each vegetation type within that corridor—agricultural field, cottonwood forest, marsh, oxbow lake, flood scour, etc.—were differently colored, the result would be an intricate and vivid mosaic, a close twining of many different habitats, sprawling several miles wide across the valley floor. Moreover, this image of diversity would be dynamic not just in space, as captured by the map, but also in

time. In 1900 the riparian corridor was an environment in rapid motion. Year by year and season by season, the mosaic changed as the river flooded, abandoned old channels, adopted new ones, and repeatedly altered ecological conditions in one location after another. From a human point of view, such a system was messy, chaotic, and frequently dangerous. It was also very inefficient in terms of providing steady, predictable, capturable outputs.

If we were next to look at a similar map for the year 2000, we would see a much simpler image. Nearly all of the riparian habitats are now restricted to a narrow corridor between levees, while agriculture and, in many areas, urban and suburban development dominate everything else. Significantly, the contemporary situation is simpler in time as well as space. The frequent shift from one vegetation type to another typical of conditions in 1900 has now become rare with the flow regime of the river tightly managed and its available floodway constrained by levees, the dynamism of the overall system has slowed to a comparative halt.

ORIGINS OF THE MODERN RIO GRANDE

To understand the transformation of the river over the past century, we need to understand the kinds of challenges faced by earlier generations of New Mexicans. By the 1870s more than 120,000 acres were under cultivation along the Middle Rio Grande, but that number soon began to decline because of upstream developments. Over-grazing, cut-and-run logging, extensive fires, the extension of roads and trails (which contributed to arroyo formation), and other factors vastly aggravated erosion throughout the watershed. The net effect was to increase greatly the river's sediment load.

During the 1880s and 90s, meanwhile, Mormon settlers brought much of the San Luis Valley of Colorado under cultivation by opening scores of new irrigation diversions on the uppermost reaches of the Rio Grande and its tributaries. These diversions had the effect of reducing downstream flows, so that not only was the river forced to carry more sediment, but it had less water with which to flush the sediment through the system. Settlement of the San Luis Valley prompted severe water shortages hundreds of miles downstream, and in the late 1880s the Republic of Mexico complained bitterly about the loss of flows at El Paso Del Norte—the area of today's Ciudad Juarez and El Paso. Agriculture there had declined by at least 50 percent, and many families were forced to abandon the area altogether.

The people of the Middle Rio Grande suffered from these changes in another way. The over-burdened and under-watered river was aggrading—the level of its channel was slowly rising due to the deposition of sediment. This loss of channel capacity made the river more prone to flooding and raised local water tables, waterlogging adjacent fields and making them more vulnerable to salinization. Because of these changes agriculture steadily declined along the Middle Rio Grande from the previously mentioned high of 120,000 acres to only 40,000 acres in the 1920s.

Society and its institutions responded. The problems of the Rio Grande, mirrored in watersheds throughout the West, helped spur development and acceptance of a new conservation ethic, which historian Sam P. Hays has aptly called the "Gospel of Efficiency." Conservationists like Gifford Pinchot, Elwood Mead, and W. J. McGee, working with Theodore Roosevelt and others, addressed themselves to the problem of harnessing and harvesting natural resources, especially rivers for irrigation and forests for timber, in order to meet the long term demands of a growing population and its increasingly industrial economy. Pursuit of this task resulted in the creation of new institutions organized to manage key lands and waters. The idea was to protect resources both from hasty and wasteful exploitation by profiteers and from piecemeal, uncoordinated development by interests to small or too inexpert to optimize their usefulness.

But the apostles of efficiency did not stop there. They sought not just to cure society of wastefulness but to purge nature of it as well, and by improving nature, to provide at the highest level more of everything society wanted, water and pasture for agriculture, timber for industry and ultimately recreational opportunities for increasingly urban population.

The apostles of efficiency viewed nature as a large machine, like a factory. The same scientific principles that rendered the factory floor more productive would also make the machine of nature more efficient. The first thing to do was to eliminate waste and superfluous movement, which was accomplished by removing unneeded parts. Among the parts to be removed were floods in rivers, freshwater flowing to the sea, fire in forests, bark beetles and budworms, predators, prairie dogs and other varmints, even porcupines. Granted that a lot of other cultural imperatives entwined with the impulse to simplify, but the impulse remains the common thread. Today we are dealing with the results of those removals in virtually every ecosystem we attempt to manage. Having removed floods and abundant water from the "machinery" of our rivers, we

now struggle to keep the Middle Rio Grande and a few similar survivors alive, while others, long dead, we treat as ditches.

INSTITUTIONS FOR THE NEW RIVER

Regardless of how we may value those removals today, it is instructive to look at what it took for them to occur. What was required for society to make so radical a change in the way it tended its land and water? First came recognition that ecological and social conditions had changed. Next came development of a social and political consensus that action was necessary. And finally it became necessary to form new institutions to execute the necessary action. In the case of the rivers, the needed institutions would provide flood control, drainage and irrigation, and minimize the instability of watersheds through forest and range management.

The history of most of those the institutions is fairly well known. In 1902 the Reclamation Service was created, and it grew into the Bureau of Reclamation. Construction of Elephant Butte Dam had begun in 1903 under private sponsorship but was soon suspended because of Mexican protests. The Reclamation Service, eager to show what it could do, took over the project and completed it in 1916. The U.S. Forest Service came into being in 1905 and in the years thereafter asserted management control over much of the Rio Grande's forested watershed.

Not all of the new institutions were federal. In 1925 New Mexicans created an institution to implement the gospel of efficiency in the valley of the Middle Rio Grande. By action of the state legislature, they formed the Middle Rio Grande Conservancy District (MRGCD), and they gave it the power to condemn acequias and to levy taxes (although the district scrupulously avoids calling them taxes).

The Middle Rio Grande Conservancy District replaced some seventy acequia headgates and ditches with four major water diversions feeding an area-wide system of high-line canals, distribution channels, and drainage ditches. Soon the new system began to achieve the economies of scale and higher efficiency in agriculture that its backers had been hoping for. There was, however, a counter current of conflict between the larger interests that profited from the new regime and the older, smaller operations that struggled to meet the higher level of capital investment required by the new system. The smaller interests protested, but they did not prevail.

Ultimately, a second set of conflicts having to do with interregional river apportionment were settled, and a permanent Rio Grande Compact became the law of the river in 1938. Two new dams supported implementation of the agreement: El Vado in 1935 and Caballo in 1938.

Then came the river's last great flood. Flows of 25,000 cubic feet per second inundated towns along the river, including Española and downtown Albuquerque. The floodwaters broke through the MRGCD's levees and destroyed much of the infrastructure that the district had built. Damage to property in Albuquerque was terrific, not least because the aggradation of the Rio Grande had brought it to a level higher than the city's downtown area. The disaster of 1941 led to congressional concern and attention, but action to correct the situation had to wait until after the conclusion of World War II.

In 1948 Congress approved the Middle Rio Grande Project and authorized the Bureau of Reclamation to dredge and channelize the river, to reconstruct levees, and to confine the river from meandering with gabions and jetty jacks and other means armoring the channel. To accomplish this work, the bureau entered into an intricate relationship with the MRGCD, a partnership that has continued to evolve, notwithstanding that the two partners have not always agreed on its terms and conditions.

Through the post-war years the bureau and the Army Corps of Engineers, in one of the unhealthiest bureaucratic competitions of all time, sought to outdo each other in building dams throughout the West. The Rio Grande did not escape their attention. Platoro was completed in 1951, Jemez Canyon in 1954, Abiquiu in 1963, Galisteo in 1970, and Cochiti in 1975.

Additionally, New Mexico finally got its share of both pork and water from the Colorado River Compact. The pay-off took the form of the San Juan–Chama project, which has authority to divert up to 94,000 acre feet of the Navajo River into the Rio Grande watershed by means of a tunnel through the continental divide. This project required its own dam and reservoir, and Heron Lake came into being in 1971.

Much of this mightily expensive new plumbing was built in the name of agriculture, but interestingly irrigated fields in the middle valley today occupy about 54,000 acres which is only about 14,000 acres more than it did in the 1920s. Use of valley lands for settlement, commerce and industry has of course produced much greater transformations and unquestionably the biggest economic impact of river control and engineering has been an enormous creation of wealth in terms of real estate value.

ECOLOGICAL CHALLENGES

Where previously the Rio Grande meandered over a flood plain that in some areas was miles wide, today we have a tightly constrained river and a small floodable area between the river levees. The transformed river is far more stable, more reliable, and more efficient than its predecessor in providing the resources and services that society identified as its highest priorities early in the last century. But the transformation has also produced an unwanted decline in ecological diversity and health, a good deal of which is attributable to the fact that the river has not flooded meaningfully in decades. This is a profound change, for river floods represent the single most powerful force in structuring the riverine and riparian environments.

The idea of a "structuring force" warrants expansion. These days we are well aware of our obligation to take care of certain elements within specific ecosystems. In the forest, it may be the spotted owl or the Jemez Mountain salamander. But taking care of individual species is hardly easy. In recent decades ecologists have learned that attempts to maximize individual variables in a complex, multi-variant system (which every ecosystem is) tend to cause the system to falter or crash. It doesn't seem to matter what the variable is. It might be board feet of lumber or animal unit months of grazing. It might be deer or codfish. The lesson seems to be that if the system managed single-mindedly for the production of one output, the overall system tends to decline, often precipitately.

On the other hand, it is impossible to attempt to manage every element of an ecosystem, for there are far too many of them. In most cases it is impossible to identify them all. Contrary, perhaps, to most people's expectation, this healthy realization does not leave us without alternatives. It leads us instead to acknowledge that, instead of trying to manage individual variables, we have to focus on trying to release the *keystone processes* that structure and shape a system. Where rivers are concerned, flooding is a keystone process. Or more accurately, the keystone process is the river's natural hydrograph—its flow regime, embracing the full pattern of high and low flows and their variability through time. In ponderosa pine forest, low-intensity, frequent fires are among the keystone processes that structure the forest system. If an ecosystem can be managed to permit its keystone processes to function in a naturalistic pattern and at a naturalistic intensity, then the individual variables, be they commodities or endangered species, will tend to take care of themselves—and persist at a sustainable level. This is a main truth that seems to be emerging these days from our experience as a scientific culture in dealing with complex ecosystems.

To return to the Rio Grande, the formerly dominant cottonwood gallery forest of the river's riparian corridor generally requires flooding to reproduce. In the absence of flooding, cottonwoods lose their competitive advantage to other plants including the Russian olive, Siberian elm, salt cedar, and other species. We are accustomed to calling these plants "invaders" as though they were launching some kind of assault. But what they are doing is not invading, they're simply making use of a heavily modified habitat that we've created and that welcomes them by meeting their needs for establishment and reproduction. Among these better adapted plants, Russian olive and Siberian elm dominate the bosque understory in the upper reaches of the Middle River where the river is degrading, while tamarisk, or salt cedar, dominate the riparian zone in the lower reach of the middle river where the Rio Grande is aggrading.

Informed visitors to the Rio Grande Nature Center in central Albuquerque will quickly note that the forest ecosystem beside the river is undergoing rapid change. They will see a vigorous understory of Russian olive lining the riverside drain. Cottonwoods provide the topmost canopy, but nearly all of these tall trees hail from the Class of '41, the last great flood and the last year of extensive cottonwood reestablishment. One looks in vain for young cottonwoods in the understory but finds instead Russian olive, tamarisk and other exotics. It is the Russian olive, not the cottonwood, that is reproducing most successfully, while the many of the older cottonwoods are senescent. Visitors who look carefully at what is on the ground, will feel their concerns grow even more acute. In most areas one finds heavy accumulations of dead wood, for there has been no flood to carry it off nor any standing water to saturate the material and speed its decomposition. One need not be a forester or ecologist to sense that the bosque in the vicinity of the nature center is unnatural-looking and very much in peril. It is ready to ignite from the first Roman candle on the Fourth of July or from a dropped cigarette or lightning strike. The native cottonwood/willow riparian systems of the Southwest are not well adapted to fire, but we have made them extremely vulnerable to destruction by fire.

Unless the management paradigm shifts, the great cottonwoods—and by extension, what we think of as the native bosque of the Rio Grande—will continue to decline and eventually perish. Not that a riparian community will cease to exist. There will always be

trees and other plants growing along the river, but the riparian community of the future will be quite different from that which evolved in concert with the river.

The traditional bosque, dominated by native vegetation, touches many a cultural nerve. As a society, we've come to value things that our forebears, who harnessed the river in service to other values, took for granted. Those formerly abundant things that are now scarce or threatened, and hence dear, include open space, woods, access to the river's edge, opportunities for recreation, solitude, contact with nature, and many living traditions both Indian and Hispanic.

The bosque also possesses an aesthetic dimension that deserves our attention, one that those who consider themselves defenders of the river would do well to bear in mind. Those who would have society change its ways should not expect to succeed by making a case based solely on fact. One has to appeal to the heart, too. And so it is important consider the beauty of the bosque—and the way the native system speaks directly to the heart. The cottonwood is an icon of the West. It's arching canopy offers shelter and shade, in a land where both are scarce. Its furrowed bole stands fast against restless skies. Most important, the cottonwood signals water amid dryness. And its fat leaves, the size of a child's hand, applaud the slightest breeze with a sound like rain. In *Great River*, Paul Horgan described the main road along the Rio Grande as, "passing in and out of cottonwood shade, a river grace." That grace, along with the bosque of the Middle Rio Grande, is today a rare and vanishing thing.

Something else that we value today, again because of its increasing scarcity, is bio-diversity, and by extension, ecological health and vigor. The river provides ample evidence that the news is not good from this quarter. Lunkers like the shovelnose sturgeon, the grey redhorse, and the freshwater drum were gone from the river by the end of the last century. Soon afterwards, the American eel also disappeared. It came as a surprise to me to learn that the common eel, which breeds in the Sargasso Sea out past the Caribbean, migrated all the way to the upper Rio Grande. We know this because the Tewa at Santa Clara and San Juan used eel skin in certain of their leggings and ceremonial dress. But eels could not make the trip after Elephant Butte Dam went into place.

THE SILVERY MINNOW

Meanwhile, at least four species of cyprinid fishes, the large family that includes carp and sunfish and most freshwater minnows, were extirpated from the Rio Grande between 1949 and the late 1960s. Probably many interacting factors contributed to the loss of these species, but chief among them were alteration of the river's hydrograph and reduction of streamflow resulting from irrigation withdrawals and reservoir storage. The diminished flows, combined with the drought of the 1950s, effectively dried up large stretches of the river for longer stretches in time and distance than had been the case before. Construction of levees and channel manipulation also simplified the river laterally, eliminating prospects for sloughs and ponds that might have functioned as refugia during times of low flow. Two of the vanished species are believed to be extinct. Two others can still be found in portions of the Rio Pecos. All of them had the bad judgement to depend upon scarce water in limited habitat, a trait shared by the last of the river's endemic cyprinids, the Rio Grande silvery minnow (*Hybognathus amarus*) which clings tenuously to life in the river whose name it bears. Once abundant from northern New Mexico to the Gulf of Mexico, the minnow clings to existence in no more than 5 percent and probably less than 1 percent of its original habitat. Unfortunately it is making its last stand in the stretch of the Middle Rio Grande most vulnerable to drying—an indication that habitat modifications in wetter stretches, including possibly the presence of exotic predators, may be even more inhospitable to the minnow than low water levels.

The silvery minnow was officially listed as an endangered species in 1994. In the following year, the minnow's terrestrial neighbor, the southwestern willow flycatcher, a typically drab and jittery *Empidonax* flycatcher that all but the most expert birders find impossible to distinguish, joined the minnow among the unhappy elect of the endangered list. The flycatcher's plight reflects a decline of the riparian environment in exactly the way that the minnow stands for the decline of the river.

These considerations compel us to view the future of the Middle Rio Grande and it's bosque with grave concern. But the context of the problem is even graver, and its severity cannot be overstated. As bad as the news may seem to be for the hammered ecosystem of the Middle Rio Grande, it describes the best situation existing on any reach of a major river in the entire Southwest. Ecologically, the native communities of the Middle Rio Grande may be on their last legs, but all other comparable systems are either prostrate or defunct. Estimates of the loss of native riparian habitat in the Southwest range from 85 to 98 percent. There is little doubt but that the bosque of the Middle Rio

Grande, among all its kindred ecosystems, is the best remaining example.

A PATH FORWARD

If the people of central New Mexico were contrarian enough to do what their neighbors in Arizona, California, west Texas, and northern Mexico have decidedly not done—that is to say, if New Mexicans elected to maintain the Middle Rio Grande and its bosque as a live river instead of a dead ditch—what would they do?

First, they would have to accept that they can't get the old river or the old bosque back. They can try to maintain a new kind of Rio Grande and a new kind of bosque within more or less present limits of constraint, which are set by the levee system. Although opportunities may exist for moving the levees back in a certain locations (notably in the southernmost reaches of the Middle Rio Grande), surrounding development makes these opportunities few. In protecting this minimalist riparian zone, river managers would not recreate a "natural" system. Indeed, in a land than has supported heavy human use for many centuries, it would be hard to choose an appropriate model for what that natural system might have been. A more reasonable goal should instead be to create a context in which naturalistic processes might continue to operate. This, I submit, is the kind of nature Americans might best hope to encounter in any of the landscapes they tend—forest, desert, riparian, or grassland. Even so, this is tall order.

Friends of the river would also accept that the future of the bosque will include exotic species. Salt cedar may not be native, and programs to control it may reduce its dominance in certain areas, but it will always be with us. So will Russian olive, Siberian elm, tree of heaven, and others. The same applies to the exotic river fishes that have found homes in the system—they are analogs to the waves of human arrivals that have swelled the population of the Southwest in recent generations.

The top priority for environmental river management is to keep the native elements of the river system present and to manage the system to allow operation of the keystone processes that favor those elements. Furthermore, we need to be prepared to accept and even promote patches of disturbance. A healthy riverine system will be a vigorous and dynamic mosaic of early, middle, and late successional gallery forests, plus ponds and lagoons, wet meadows, sandbars, and scour areas. This kind of continuous renewal is often hard for people to accept. When we see something we like—a stand of towering cottonwoods, for instance—we're inclined to say, "hold it right there, don't change a thing." But we ignore at our peril the truth that nothing holds still for long, not our children, ourselves, nor the manifestations of the natural world around us. If we really want to keep the things we value most, we have to learn to roll with the system's inherent dynamic of change. This is especially important when we deal with the exceptional dynamism of a riparian system like that of the Middle Rio Grande.

The key to management of a renewed Rio Grande will be to manage the plumbing of the river, including all its dams, drains and diversions, to mimic as closely as possible the natural hydrograph of the river. This means that flows would spike and fall in the seasonal pattern that characterized the river's behavior before it was dammed. The hydrograph is the keystone process we most need to honor. A central element of such an effort would be to arrange as often as possible for overbank spring floods, still within the levees, to promote regeneration of cottonwoods, to speed decomposition and recycling of nutrients, to carry off or dampen understory fuels, and so forth. It is probably not important for us to enumerate all the things floods do for the system. In fact, we probably cannot catalog them all, anyway. We mainly need to know that the system works much better with them than without them.

Having floods, incidentally, requires having a levee system capable of accommodating and withstanding high flows. There is no small irony here that levees are important, not only to protect us from the river, but to protect the river from our diminishment of it. Within the levees, the river can perhaps be permitted to behave like a river.

These prescriptions for keeping the river and the bosque alive are presented in an unusual study, of which any serious student of the Rio Grande should be aware. This interagency study drew on the resources and expertise of the U.S. Fish and Wildlife Service, the Bureau of Reclamation, and the Army Corps of Engineers, under the direction of professor Cliff Crawford, of the University of New Mexico. It was completed in 1993 and is generally known as the Bosque Biological Management Plan. Essentially, this study identifies the principal management goals that must be achieved if the Middle Rio Grande is to remain a live river with a surviving native bosque. Understanding those goals is a vital first step, but the hardest work still lies ahead.

The most daunting thing in the middle river is not understanding the natural ecology of the river. The most daunting problem is its contending with its political

ecology. The fate of this long, thin ribbon is controlled by no less than four counties, nine towns and cities, six pueblos, four federal agencies, five state agencies, the Interstate Stream Commission, and the Middle Rio Grande Conservancy District. The complexity of our contemporary world makes it relatively easy to hobble or stop complicated undertakings. With consensus difficult to achieve and veto power widely shared, it is infinitely harder to resolve complex matters, even when such resolution promises to benefit all affected parties.

True conservation management of the Middle Rio Grande would indeed be complex. The challenge is to get all the interested entities, all of the complex political ecology, working in the same direction. In the end, the choice between a landscape embodying complex or simple nature, between a live river or a dead ditch, will come down to choices about use of water. Maintaining remnant cottonwood and willow bosque via flooding, for example, raises the question of whose water will be used for the flood and where will that water go? Having floods means having a place to put the floodwaters after they run through the system we wish to treat. This may prove to be a significant obstacle to restoring floods to the system.

Rivers like the Rio Grande need "prescribed floods" in the same way many forests and grasslands need prescribed fire. In both cases the prescription is to restore a keystone process. One place where prescribed floods have been used effectively and recently, is on the main stem of the Colorado. Intentional high volume releases from Glen Canyon Dam in 1996 produced a salutary effect on the ecology of the Grand Canyon. Hopefully, the means will be found to continue that kind of practice in the future. But on the Colorado, the managers had the huge capacity of Lake Mead, downstream, to absorb those waters.

The Middle Rio Grande lacks that kind of capacity. Under certain circumstances Elephant Butte Lake may serve to accommodate floodwaters, but sedimentation has greatly reduced its original capacity, and interstate and international agreements make its management far from flexible. Moreover, every drop of water in the river is spoken for. In a sense, so extensive is the accounting of water rights on southwestern rivers that every drop in every stream is owned by someone—or more accurately, a succession of someones—even before it falls from the sky as snow or rain. It used to be that floods were considered an act of God. One might say that the "waste" of water was charged to His account. But after nearly a century of dam and levee building in the spirit of the gospel of efficiency, only the most extraordinary weather conditions today produce volumes of water that exceed the capacity of the system to control, store, and mete out according to plan.

Nowadays most floods must necessarily be acts of man. In a watershed, where every acre-foot of water is allocated and owned, even before it exists, even before the water molecules that comprise it are deposited in the form of rain or snow, the intentionally permitted disappearance of water must theoretically be debited to someone's account. Exceptions do exist, but they are small and rare.

Floods do not occasion the only or even the greatest need for the allocation of water to environmental purposes. Maintaining minimum flows in certain habitats to sustain endangered species can consume much larger amounts of water. In either case, a clear need exists to create what we might call "water entitlements" for individual rivers like the Rio Grande. This is a decidedly post-modern concept, reaching far beyond the ordinary bounds of irony. To argue that rivers are entitled to a share of the water they carry might in other times and places seem unnecessary but not in the contemporary Southwest, where neither the laws nor practices of the past century and a half are sympathetic to any but a utilitarian view of the waterways that make our oasis civilization possible.

Perhaps one day, such thinking will seem as strange to our successors as belief in the divine right of kings now seems to us, but in the meantime, those who would endow our rivers with water must find that water within the existing legal and administrative system. One obstacle to doing so is the prevailing myth that western water allocation is a zero-sum game—that all water is fully and precisely allocated, subject to water rights defined with crystal clarity, and that the systems that use this water run with the precision of a Swiss watch. According to this line of thinking, any reordering of such a system will blow its precision to smithereens.

The reality, however, is quite different. Look closely at any cluster of water rights and uses, and you quickly learn that uncertainty abounds. Who owns exactly what? Who has used how much water, and for how long? Precise answers to such questions turn out to be surprisingly hard to come by. On the Middle Rio Grande, for instance, the water rights of the MRGCD have never been definitively quantified—notwithstanding that the district is now nearing eighty years of age. Besides the existence of many conflicting and competing paper claims to water, a lot of water is used inefficiently. Every system leaks. Most systems operate as much on assumptions as hard data, and only rarely are those assumptions entirely correct. This is not a

Swiss watch. It is more like a sundial on a partly cloudy day.

Precisely because there is flex in the system, opportunities exist to secure water for the Middle Rio Grande without injury to current holders of water rights. Public agencies, like the Bureau of Reclamation, already lease water on the open market from willing sellers like the city of Albuquerque. At some time in the future one or more pueblos along the Rio Grande may choose to disentangle their water rights from those held by the MRGCD and similarly lease water for environmental purposes.

Donations might also be made. A municipality like Albuquerque might voluntarily contribute water to a river entitlement as a means of inspiring greater water conservation among its citizens.

The biggest opportunities, however, lie with agriculture. The long-term trend throughout the West is for agriculture, which uses approximately 80 percent of all water, to become more efficient, and for the water thereby saved to be reallocated to urban and industrial uses. When such reallocations occur, a portion of the redirected water should be reserved for environmental protection. Urban purchases of water can pay for conservation infrastructure—field leveling, drip systems, canal lining, computerized transmission control, etc.—so that agricultural production and economic activity does not diminish. Similarly, federal or state funds might pay for infrastructure that frees up water for endangered species protection. Or funding might directly pay for fallowing or forbearance during drought years in order to provide water for minimum flows.

The mutually beneficial alternatives, while perhaps not profuse, are nonetheless not scarce. The greatest obstacle to progress in maintaining the life of the Middle Rio Grande is the reluctance of vested interests to contemplate them with an open mind.

Inaction, however, is not the only danger. Obedient to the law of economics, the managers and constituents of our hypothetical water entitlement would seek to maximize use and minimize costs of the system and endeavor to buy, donate or require only as much in the way of rights for ecological uses as is considered absolutely needed. How much is that? Unfortunately, such a question can never be fully resolved, for it can only be answered in terms of current knowledge, on which full agreement never exists.

(Indeed, it's reasonable to question the security of all our assumptions about water availability. Most data indicate that during the quarter century from 1970 to 1995 we enjoyed one of the wettest pluvial periods in recorded history. Indeed, if we consult prehistoric measures, we seem to inhabit the wettest period of the last two thousand years. This realization should inspire an ethic of restraint in the society of the Southwest, but it goes largely ignored.)

A GLOBAL CONTEXT

The literature on a wide range of attempts to manage sustainable harvest of natural resources—acre-feet, board feet, animal unit months of grazing—surfaces three fatal problems that lead virtually all of these attempts to failure. The three themes or characteristics include:

- An inevitable push to maximize economic returns
- The use of operational models built on current knowledge, which is never complete and on which there is never full agreement
- The lack of full agreement on the scientific "facts of the situation," which effectively throws decision making into the political and economic sphere and further guarantees overuse

These implacable conditions describe the bleak endgame of water allocation in the American Southwest, and every man, woman, and child who lives within the compass of the Rio Grande is in it.

The question facing New Mexicans is this: Will we place ourselves enough ahead of the curve of thirst and urgency to create a buffer and to tithe a portion of the water with which we are blessed to the system that provides it? Such a tithe need not be made purely from a sense of moral obligation. There can and should be self-interest in such an act. Anything set aside, any flex in the system, anything that is not allocated to current consumption and use, becomes a buffer against uncertainty. It becomes a buffer against the droughts and other surprises the future inevitably brings. Saving something for the river, saving something for the system, creates a reserve from which people will also benefit. Not least, it checks the development of ever higher and less sustainable levels of dependency.

In contemplating their water future, the people of the Middle Rio Grande would do well not to lose sight of two ideas: the first is that the MRGCD, by far the region's greatest consumer of water, is not the problem. The MRGCD is the solution. The MRGCD, together with state and federal agencies, should pursue an aggressive and thorough examination of its operations to determine where and how water might

be saved by achieving a higher level of efficiency. Having determined how to save water, the district can then calculate how much the savings will cost and it can begin selling the saved water at a reasonable rate, while in the process upgrading its infrastructure to a more efficient, easier-to-manage state. It can reduce operating costs by selling water for the cost of the capital to save that water.

The second idea this: the silvery minnow, the endangered species that has engendered so much litigation and debate over the use of water in the Middle Rio Grande, is not a curse on the region. It is a blessing. At present, that tiny fish, only a couple of inches long, is the only thing that prevents the Rio Grande through Albuquerque from becoming like the Rio Grande through El Paso. Or the Salt River through Phoenix, or the Santa Cruz through Tucson. I will wager that nearly every person who reads this article has been to one or more of those cities. And I will wager that none of them made an effort to notice where those rivers were. That is because there's nothing much to notice. They are ditches, nothing more. Unless the paradigm of management changes, the Middle Rio Grande may suffer a similar fate.

The silvery minnow may save the region from itself. It is there to remind everyone—city-dwellers, farmers, tribes, and visitors—that we owe more to the places we inhabit than simply the pursuit of the next increment of profit and convenience.

It is worth remembering that all attempts to use or alter the land are attempts to tell a story about how we think the land ought to be. What we find over and over is that these stories we tell are inevitably simpler than the land itself. We cannot escape from geography; we are embedded in it. And the test of our character, as a people embedded in geography, is how well we keep our stories current—how intelligently and effectively we respond when we learn that they are out of date and that they require revision. The question before all of us who depend in one way or another on the Middle Rio Grande is whether we will revise our story about life in this place in a way that keeps a living river in it.

This is the story of many people. It is their *history*, working itself out, day by day and home by home. This class of problem, which involves choosing between an accommodation of complex nature and the relentless pressure of economic compromise, is the problem of the people of the Middle Rio Grande as much as it is the problem of people anywhere in the world. How those of us who are alive today resolve this problem—or fail to resolve it—will afford future historians many insights about the character of our time and place and about the kind of people we have chosen to become.

Suggested Reading

Salt Dreams by W. E. deBuys, University of New Mexico Press, 1999.

Conservation and the Gospel of Efficiency—the Progressive Conservation Movement, 1890-1920 by S. P. Hays, University of Pittsburgh Press, 1999.

Barriers and Bridges to the Renewal of Ecosystems and Institutions by S. Light, L. Gunderson, and C. S. Holling, Columbia University Press, 1995.

Great River: The Rio Grande in North American History by Paul Horgan, Wesleyan University Press, 1991.