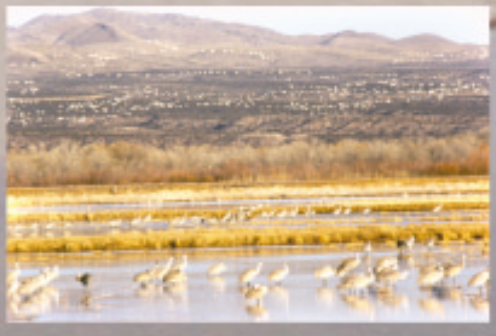
Middle Rio Grande Ecosystem Bosque Biological Management Plan
The First Decade: A Review & Update









Middle Rio Grande Ecosystem Bosque Biological Management Plan

The First Decade: A Review & Update

By Lisa Robert

Project Coordinator: Deborah Hibbard, Rio Grande Restoration

Prepared in cooperation with the Middle Rio Grande Bosque Initiative and the Bosque Improvement Group

Albuquerque, New Mexico
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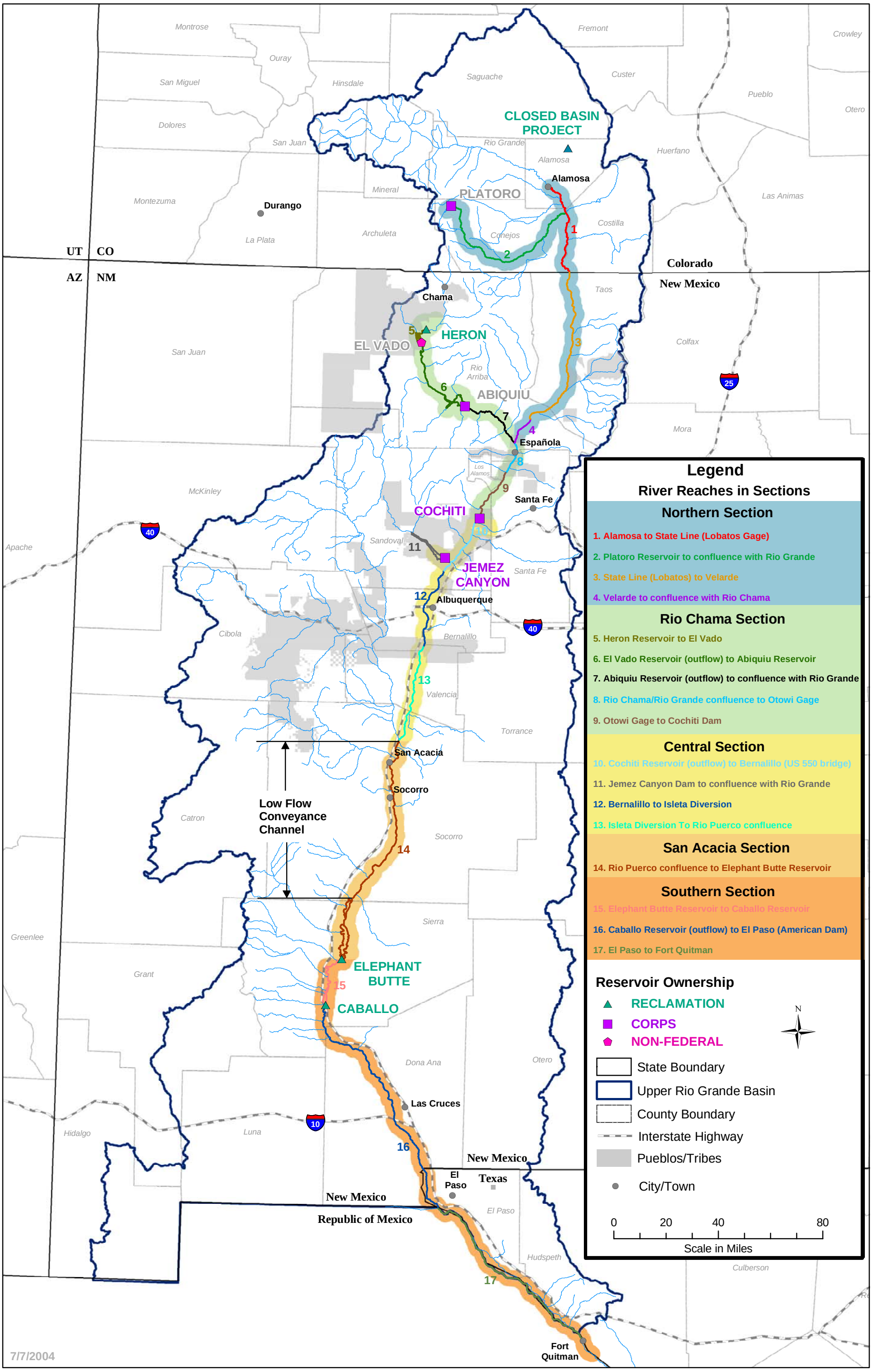
"*Those who say it cannot be done should not interrupt the people doing it*."

(Chinese proverb)

Table of Contents

Appendices

Figures



Map 1-1. Watershed and Key Water Operations Structures in the Upper Rio Grande Basin

Foreword

By Cynthia G. Abeyta
Coordinator, Middle Rio Grande Bosque Initiative/Bosque Improvement Group

In 1991, grave concern for the health of the cottonwood bosque in New Mexico's central Rio Grande valley initiated Congressional appointment of a Rio Grande Bosque Conservation Committee. With broad public input, the nine citizen members of the committee examined problems affecting the Middle Rio Grande riparian corridor and ultimately submitted a report to the Congressional Delegation, recommending that a Biological Interagency Team be formed to create a biological management plan for the long-term protection of the bosque from Cochiti Dam to the headwaters of Elephant Butte Reservoir.

The *Middle Rio Grande Ecosystem: Bosque Biological Management Plan* (Crawford, et al., 1993) was released in 1993 and since that time it has been an integral part of restoration activities occurring in the Middle Rio Grande. The twenty-one recommendations made by the Biological Interagency Team set the stage for a new era in management of the Rio Grande bosque, and have served as planning guides for land and water agencies, scientists, conservationists, and those concerned with maintaining and improving the health and management of the ecosystem.

Following release of the plan, Congressional funds were appropriated to the U.S. Fish and Wildlife Service to create and support a central coordinating structure that would oversee implementation of the management plan's recommendations. The Middle Rio Grande Bosque Initiative (Bosque Initiative) was created in 1994 and has been funded through annual Congressional appropriations. Its goals are to protect, enhance, and restore biological values by addressing ecological functions within the Middle Rio Grande, using the recommendations cited in the Bosque Biological Management Plan. The Middle Rio Grande Bosque Initiative has been guided since 1995 by the Bosque Improvement Group (BIG), an informal, nonexclusive forum for those interested in bosque management within the Middle Rio Grande. Participation in BIG is extensive and diverse, and includes engineers, scientists, educators, administrators, tribal members, historians, farmers, private landowners, and others concerned with the health and preservation of the Middle Rio Grande ecosystem.

The Bosque Initiative/BIG has funded numerous projects in Research, Monitoring, Habitat Enhancement/Restoration, and Public Outreach, each dedicated to implementing one or more of the recommendations identified in the *Bosque Biological Management Plan*. Through the continued support of Senators Pete Domenici and Jeff Bingaman, and the participation and encouragement of their staffs, tremendous progress has been made towards the goals of BIG and the Bosque Initiative. Accomplishments (see http://mrgbi.fws.gov/) include: restoration of thousands of acres within the Middle Rio Grande; better understanding of the region's natural resources through research; identification of project successes through biological monitoring; and the education of thousands of individuals who have participated in Bosque Initiative and BIG outreach activities. Sincere gratitude goes to Senators Domenici and Bingaman and their staffs for the necessary funding to accomplish this work.

Recommendation #20 of the *Bosque Biological Management Plan* calls for periodic review and update of the plan in order to realize its potential for influencing management decisions that affect the Middle Rio Grande riparian ecosystem. This document, the *Middle Rio Grande Ecosystem Bosque Biological Management Plan, The First Decade: A Review & Update*, is the first such review, and constitutes a

supplemental volume to the original plan. It provides a unique history of the years since the *Bosque Biological Management Plan* was published, and thus a context for measuring the progress made toward plan implementation. It also describes an integrated 'ecosystem approach' to restoration, and suggests a number of avenues for future action.

Funding for production of the *Update* was provided by the Middle Rio Grande Bosque Initiative. The Bosque Initiative and BIG are most grateful to Rio Grande Restoration for taking on the contract for producing the *Update*. Special appreciation goes to project manager Deborah Hibbard for her dedication to the multi-year production of this document; her persistent support of the Bosque Initiative and BIG; and her vision and commitment to a renewed river ecosystem. Special appreciation also goes to Lisa Robert, the *Update's* author. A local historian, author, editor, and farmer, Robert has been a participant in the Bosque Initiative and BIG since their commencement in 1993. She incorporates into the *Update* information compiled from personal notes taken over the past decade, and from interviews with many individuals involved in both environmental restoration and water management in the Middle Rio Grande.

We are confident the *Bosque Biological Management Plan Update* will further inspire an ecosystem approach to the protection, enhancement, and restoration of biological values within the Middle Rio Grande.

Preface

By Clifford S. Crawford

The surge of attention paid to the Middle Rio Grande and its riparian forest, the bosque, during the past decade was a pleasant surprise to many of us concerned about the future of these historic New Mexico landmarks. This remarkable update of the *Middle Rio Grande Ecosystem: Bosque Biological Management Plan* details that surge in chronological order, and documents how the concept of "ecosystem" has become increasingly acceptable to resource management agencies and stakeholders sensitive to the issue of river regulation. The *Update* also strongly implies that such acceptance was stimulated by the 1993 publication of the *Bosque Biological Management Plan*, which used "ecosystem" as an integrating theme throughout its text and in its twenty-one concluding recommendations.

The subsequent creation of the Bosque Improvement Group (BIG) was another unexpected event. BIG resulted from suggestions described in the last chapter of the *Management Plan,* proposing a representative council to implement and coordinate all of the plan's recommendations. Councils of several kinds did arise, and eventually fade. BIG, however, did not fade. It was and still is headed by the Middle Rio Grande Bosque Coordinator, an employee of the U.S. Fish and Wildlife Service. Since 1995, this "informal ad hoc nonexclusive think tank" has been a peer-review forum responsible for implementing the *Bosque Biological Management Plan's* goals relating to hydrology, terrestrial and aquatic habitats, monitoring and outreach. BIG's inclusive funding effort has led to a diversity of studies and programs that contribute greatly to our understanding of the bosque's role in the Middle Rio Grande ecosystem and have served to involve the greater public.

The generally positive reception to the *Bosque Biological Management Plan* and to BIG is gratifying, yet it would be unwise to allow that sentiment to mask the environmental realities of demographic change in the Middle Valley. There is now little doubt that the demands of our rapidly expanding population on the Rio Grande basin's capacity to deliver water will have a critical impact on the future of the river and its most obvious asset, the bosque.

I still expect the bosque, in one form or another, to be around for a long time to come, considering its broad appeal to New Mexico's citizens and visitors. What will that form be in a chronically water-stressed riparian landscape? The *Bosque Biological Management Plan* indirectly addressed that question in many of its recommendations, although back in 1993 there was no way of knowing how acceptable those suggestions would be. Indeed, the first recommendation, with its emphasis on mimicking the river's "typical natural hydrographs," generated responses ranging from deep skepticism to wild enthusiasm. Fortunately, as the *Update* illustrates, most if not all of the recommendations have received at least thoughtful attention, and have found their way into ongoing or anticipated efforts to "restore" the bosque.

The survival of either a functionally restored or an otherwise untreated bosque will in the final analysis depend on its access to river water. Thus a big question ahead concerns the "connectivity," or hydrologic linkage, between the bosque and the river, and the linkage of both of these ecosystem components to the aquifer beneath them. Only a heightened public awareness of this relationship, and a determination to keep that awareness in mind when establishing environmental policy for the Middle Rio Grande, will assure the continuation of a relatively sustainable Middle Rio Grande ecosystem.

The *Update* records the progress made toward resolving this issue over the past decade. It weaves an account of how stakeholders, resource agencies, scientists and policy makers are reworking earlier approaches to managing both central New Mexico's "ribbon of green" and the river on which it ultimately depends. The account is replete with insightful and sometimes colorful opinions by quotable participants. It takes the reader year by year through events and debates that in turn led to key management decisions and interesting political opportunities, or sometimes led nowhere.

The *Management Plan's* twenty-first recommendation has been and surely will continue to be the most challenging to implement. It is also, in my clearly biased opinion, absolutely essential. It calls for *integrating* resource management so as to focus on sustaining and enhancing the "biological quality" and "ecosystem integrity" of the bosque, the river, and its adjoining floodplain. The first of these terms refers to "the diversity and abundance of species – coupled with the environments and ecological processes that sustain them." The second refers to the "capacity of the ecosystem to return to an organizing, self-correcting condition following a major disturbance."

The *Bosque Biological Management Plan* is essentially an argument, and the *Update* reveals how that argument has played out so far. It also raises questions about future management directions. For example, should we as a highly mobile society fit our needs to those of a sustainable riverine/riparian ecosystem, or should we try to fit the ecosystem to our own, ever changing way of life? The answer, I think, is to attempt to do both. Let me suggest several approaches that I believe are mutually compatible.

One is to carefully alter the ecosystem by making it resemble, in structure and function, that of the pre-regulation past. Think of this as a form of restoration in which the resulting mosaic of largely native vegetation enhances habitat diversity, conserves the basin's water, and reduces the intensity of bosque fires. Of course, all that will have to be done mainly within the confines of the existing levee system, and/or other suitable boundaries. Reviews of this concept are now underway at the agency level, as are early efforts to implement it.

A second approach is to make portions of the bosque more accessible and "fun" to visit in order to enlist the public's imagination and support. Especially in urban areas, segments of the riparian corridor could be made more attractive to those who otherwise shy away from getting too close to Nature. It might mean creating bosque 'parks,' with trees and shrubs spaced mainly for play and picnic. On the other hand, for those who prefer to visit wilder sites, destinations like the Rio Grande Nature Center in Albuquerque would still be rewarding. Whatever shape controlled and designed access to the bosque takes in the future, an increased visitor population will also generate employment opportunities for service personnel, park police, and concession operators. A flexible park concept, if meshed with the greater vision of a healthy riparian mosaic, could produce a riparian environment in the middle Rio Grande with much broader public appeal than exists for the bosque of today.

My third suggestion also involves carefully bringing more people to the bosque, this time to study and record its changing structure and functioning. The Bosque Ecosystem Monitoring Program (BEMP), continuously supported by the Middle Rio Grande Bosque Initiative/BIG since 1995, uses students and teachers to monitor key indicators of bosque health. Under close supervision by trained interns, scientists and educators, youngsters gather monthly data on a set of basic physical and biological variables at twenty-two similarly constructed sites along the Middle Rio Grande. Once thoroughly analyzed, the information is used by resource management agencies such as the U.S. Army Corps of Engineers, the Middle Rio Grande Conservancy District, and the City of Albuquerque. It is also made available to the research community and to the public at large. BEMP is a successful and thrifty model for gathering important data, and for bringing together different elements of society in the common cause of sustainable ecosystem management.

In order for the bosque and the river to retain any semblance of what they are now—or what they might have been during their early exposure to human culture—they will obviously have to be managed in the context of what happens to water in the rest of the Rio Grande basin. The revealing story of bosque-related events told in this *Update* is but one chapter in the unfolding history of the basin's water management. How valuable is history as a guide for future bosque and river management? Can we learn from an account of how citizens and governments shape the future of such resources? What do you think?

Introduction

In the first years of the 1990s, United States Senator Pete Domenici's Rio Grande Bosque Conservation Committee brought federal dollars, political attention, citizen input, and academic resources to bear on the unique riparian corridor of the central Rio Grande from Cochiti to Elephant Butte. During those same years, an ad hoc gathering of federal, state, and local water managers, academics and technical experts known as Rio Grande Joint Initiatives began exploring a blueprint for agency cooperation and information sharing that acknowledged for the first time the interrelatedness of their various missions. Both endeavors represented a trend toward coordinated management of the river system and a more holistic view of its physiology. For a maze of reasons, however, attainment of those goals would be easier said than done.

What was known about the hydrology of the Middle Rio Grande changed drastically in the early 1990s. *A Hydrogeologic Framework of the Northern Albuquerque Basin,* (Hawley and Haase, 1992), and a U.S. Geological Survey (USGS) report on groundwater flow in the Albuquerque Basin (Thorn et al., 1993) both indicated that the basin's aquifers were not as well connected to the surface waters of the Rio Grande as previously thought, and that serious drawdowns were occurring as a result of municipal pumping, a revelation which sent the City of Albuquerque—and eventually the state—in entirely unforeseen water management directions. Overnight, the Middle Rio Grande Council of Governments' four-volume set of water planning guidelines for the region was woefully out of date, and there was demand for a new and more public process of regional water planning. Water was, in fact, the key ingredient for a whole quilt of intentions: the City of Albuquerque and Bernalillo County produced a joint groundwater policy and protection document (Albuquerque/Bernalillo County, 1993); the Middle Rio Grande Conservancy District (MRGCD) drafted its first-ever water policy plan (DuMars and Nunn, 1993); the City of Albuquerque formulated a management plan for Rio Grande Valley State Park (City of Albuquerque, 1993); and the U.S. Fish & Wildlife Service prepared to list the Rio Grande silvery minnow as an endangered species. Against this flurry of territorial agendas, another document stood out. It was the *Middle Rio Grande Ecosystem: Bosque Biological Management Plan*, (Crawford, et al., 1993) and it alone took into account the long-term health of the whole river system in which every other plan was grounded.

The information in the *Bosque Biological Management Plan* was absorbed slowly into public consciousness like a time-release remedy. Change did not occur, as the plan's creators imagined, through the legislative establishment of an advisory board charged with oversight of the riparian forest called the bosque. Rather, the plan broadcast the seeds of an "ecosystem approach" that have quietly taken root in the soil disturbed by endangered species and water right battles of the past decade. Today, words like *riparian*, *aquifer,* and *ecosystem* are most certainly part of the public's vocabulary, and local bureaucracies are far from oblivious to the environmental repercussions of the policy decisions they make. Even better, surprising combinations of players have come forward to implement the Bosque Biological Management Plan, and its twenty-one recommendations have proven stunningly thorough: they still represent the most comprehensive and practical guidelines for healthy river management in the Middle Rio Grande.

An ecosystem is an entire community of organisms, along with the environment on which they all depend. Where humans live in great numbers, their attitudes, practices, and politics are as critical to ecological health as sunshine, air, and water. Part I of this *Update,* entitled "A Decade In Context," offers an abbreviated, year-by-year catalog of milestones and epiphanies that have occurred in the Middle Rio Grande since the *Bosque Biological Management Plan* was published in 1993. The chronology is far from comprehensive; rather it is intended to sketch the upheavals in thinking that we who live here have undergone, and what this ideology means for the future of the bosque, the hard-working Rio Grande, and very likely, for our continued occupancy of its life-giving basin.

It stands to reason that the common denominator of a riparian ecosystem is water. The Rio Grande is a snowpack-melt hydrograph river with natural high flows occurring from mid-May to early June. But modern flood control and water storage practices, along with the infrastructure and delivery schedules that accompany such alterations, have affected this intrinsic flow regime and all aspects of river morphology and ecosystem health.

The 1994 listing of the Rio Grande silvery minnow as an endangered species fostered a split in restoration thinking, and provoked a minnow *vs.* ecosystem debate over how to achieve it. Now, after seasons of struggle to maintain minimum flows for a single species of fish, wisdom is pointing back to a more holistic view: only by supporting the river's natural functions can we begin to assure the condition of its dependent species.

In Florida's Kissimmee River Basin, a model for rehabilitation has long been underway, and respect for four fundamentals—water quantity, water quality, and the timing and distribution of flows—is restoring hydrologic function to a degraded system. Those same principles can certainly be applied in the Middle Rio Grande to recreate a more naturalized river. Part II of the *Update*, "An Ecosystem Approach," presents an overview of central Rio Grande watersheds, flow regime, sediment transport, and surface/groundwater connections as modified by present day development and urbanization.

A variety of experts believe that unhealthy trends in the middle basin may eventually be reversed, and that the river can be managed more naturally within the constraints of the modern system using a scaled-down version of basic river processes. But recovery will also require dependable mechanisms for coordinating and funding ongoing research, monitoring, restoration, and outreach programs; a peer review process for evaluating and modifying the work in light of new findings; a strong regional ethic regarding water conservation; and accord between the agencies that manage water resources in the basin. In other words, restoration must happen not only in the physical sense, but in the socio-political arena as well. Part III, "Getting Real," suggests some crucial adjustments that will have to be made regarding programs, policy, and public attitude if we are to achieve the goal of sustainable ecosystem health in the Middle Rio Grande.

Part One: A Decade In Context

There are turning points in the history of any place, and 1993 was such a time for the Middle Rio Grande, the roughly 160-mile-long stretch between Cochiti Dam and Elephant Butte Reservoir where a majority of the state's population resides. In rapid succession the inhabitants of the region learned that the Rio Grande, which bisects New Mexico like an aorta, had been declared the most endangered river in America by a national environmental organization; that a fish species which had evolved in concert with the Rio's natural ebb and flow was now simply ebbing; and that the revered riparian forest known as the *bosque* was well on its way to what biologists termed 'senescent decline.' Equally sobering, the disarming myth of an accessible Lake Superior beneath thirsty, booming Albuquerque was superseded by a far more conservative picture drawn with a U.S. Geological Survey groundwater flow model (Kernodle, 1986). The appearance of so many red flags at once suggested that all manner of practices and beliefs about water in the middle valley were in need of drastic reform. Of course, there had been intimations of coming shifts in the paradigm for some time.

Elephant Butte Reservoir filled to capacity and 'spilled' in 1985, canceling an almost perennial Rio Grande Compact debt to Texas by the upstream states of Colorado and New Mexico. The following year, with high water spreading out across the floodplain below El Paso and nowhere to hold the precious surplus, Texas asked for a Congressional reevaluation of the current Rio Grande Operating Plan in hopes that the U.S. Army Corps of Engineers would offer up conservation storage at Abiquiu Reservoir. A subsequent analysis of federal reservoir operations on the Upper Rio Grande (U.S. Army Corps of Engineers, 1989) found there was little to be done about spilled water, but the study did bring to light a number of "environmental enhancements" that could be accomplished under existing authority. Henceforth, the U.S. Fish & Wildlife Service would be afforded a seat at the water managers' table.

Congress authorized the storage of native Rio Grande water in Abiquiu Reservoir in 1988. At the same time, 24.6 miles of the Rio Chama below El Vado Reservoir was designated as 'Wild and Scenic River,' and so it was that a brown trout fishery operation, along with rafting and other recreational interests, became the drivers for a hallmark flow agreement developed by state and federal resource agencies along the Chama. The Rio Chama Management Plan (Fogg et al., 1992) represents the first coordinated effort to append 'additional benefits' to standard Rio Grande water operations.

That same year, University of New Mexico professors Cliff Crawford and Manuel Molles offered a first-ever course in Bosque Biology, and launched a long-term study of the effects of flooding on the central Rio Grande's unique riparian cottonwood forest. The health of the bosque would prove to be inextricably connected to river management at every level.

Figure 2. Cottonwood bosque along the Rio Grande.
(Photo by Kim Eichhorst Mitchell)

Rio Grande Joint Initiatives

With progress on the Rio Chama flow agreement fresh in their repertoire, U.S. Army Corps of Engineers, Bureau of Reclamation, Bureau of Land Management, and U.S. Fish & Wildlife Service personnel wondered if other basin sticking points might be addressed through informal discussion. In the spring of 1990, they convened a casual working group of scientists, water managers, and government folk, and over the course of the next five years, Rio Grande Joint Initiatives became an unofficial blueprint for teamwork across resource agency lines.

The first modification to water operations that its members undertook was a minimum flow agreement for the Cochiti-to-Isleta reach of the river. To meet new requirements for its wastewater discharge permit, the City of Albuquerque needed increased flows to dilute effluent being released to the river. Joint Initiatives helped negotiate an agreement to allow the Middle Rio Grande Conservancy District to use 20,000 acre-feet of Albuquerque's San Juan Chama water annually, in exchange for keeping 250 cubic feet per second (cfs) flowing past the municipal wastewater treatment plant.

Another proposition evaluated by Joint Initiatives' members involved the re-regulation of Cochiti Lake to house a 5,000 acre-foot irrigation pool for the Middle Rio Grande Conservancy District. Water for irrigation is released down the Rio Chama from the MRGCD's storage reservoir at El Vado; if a rainfall event occurs downstream and the irrigation water is not needed after it has been released, Cochiti represents the last place the water can be temporarily held up. But the re-regulation proposal garnered a negative report. A record pool had occurred at Cochiti in 1987, leaving a bathtub ring of dead trees and debris at the upper end of the lake. Landowners, including the Pueblo of Cochiti, Bandelier National Monument, and the U.S. Forest Service, were understandably unhappy. In time, however, a delta of rich, wetland habitat developed where nothing of the sort had existed before. It soon became a positive draw rather than an eyesore, and when temporary storage of irrigation water was proposed for the lake, an interagency study team concluded that the threat of inundating the delta outweighed the projects' benefits.

Joint Initiatives' members also evaluated the possible early release of Albuquerque's San Juan-Chama water from Abiquiu Reservoir in years of high runoff to mitigate adverse impacts on rafting and recreational uses of the reservoir. Erosion problems on the Rio Chama and lack of a destination for the evacuated water eventually doomed that proposition, too.

At what turned out to be the final meeting of Joint Initiatives in March of 1995, attendees identified the Rio Grande bosque as the next likely arena for interagency collaboration. Shortly thereafter, a new entity, the Bosque Improvement Group (BIG), assumed a similar "dispense with red tape and roll-up-the-sleeves" attitude, and the wholesome genes of Rio Grande Joint Initiatives were passed on.

In late April of 1990, New Mexico State Engineer Steve Reynolds—chief administrator of private and public waters for more than thirty years—died. Reynolds also served as Interstate Stream Commission secretary and engineer, and had thus almost single-handedly determined how water was shared among New Mexico's citizens and with its neighbors. But times were changing and his successors inherited a crumbling estate. Water was being under-delivered to downstream users of the Pecos and the Rio Grande, and indeed, New Mexico was soon to lose a case before the U.S. Supreme Court regarding Pecos River obligations to

Texas. Not even a fifth of the state's water rights had been adjudicated, including those guaranteed to Native American tribes. In the Middle Rio Grande, there appeared to be a widening discrepancy between irrigation allocations and how much water was actually being diverted. Metering was nearly nonexistent, developers and municipalities were being allowed to pump groundwater without retiring surface rights to offset effects on the river, and thousands of new domestic well permits were being issued each year. Not least, State Engineer Office records were still being kept with pen and paper.

Now, one by one, the issues that would make headlines in the water world of the 1990s began to emerge.

In June of 1990, the University of New Mexico Faculty Scholars Program hosted a "Conference on Global Climate Change and the Rio Grande Basin." Attendees from around the world advocated using the region as a "living laboratory" for studying the impacts of global climate change. New Mexico, they warned, is the meeting ground of several distinct climate zones and where such zones overlap, the effects of climate change are likely to be greatest. In recognition of this, state and federal agencies agreed to set up Long Term Ecological Research Centers at Sevilleta National Wildlife Refuge and in the Jornado del Muerto to begin monitoring the basin.

Within a year, a unique interdisciplinary program was underway at the University of New Mexico to explore the interactions of geology, hydrology, geomorphology, chemistry and biology in the mid-Rio Grande. Understanding the relationship between surface water and groundwater was at the heart of the work and early on, the research affirmed that unlike more water-rich regions where sloping, mesic soils typically contribute water to nearby streams, in the semiarid southwest, streams are often the *source* of groundwater. Investigators also confirmed that certain reaches of high desert streams intermittently dry up when porous stratigraphy and riparian vegetation absorb all of the available surface moisture.

The "hydrogeoecology" program was also contributing significant discoveries about the effects of periodic flooding on the Rio Grande bosque. Biologists began to describe a 'mosaic' of native vegetation that had once waxed and waned across a wide floodplain, in tune with cycles of flood and drought. But half a century of flood control and water development had exacted a toll, and a now-static community of aging cottonwoods was giving way to invasive species that were taking advantage of the altered flow regime.

These studies came to the attention of New Mexico's senior U.S. Senator, Pete Domenici, and in September of 1991, he announced the formation of a Rio Grande Bosque Conservation Committee to study what might be done to assure the continued existence of the southwest's largest riparian cottonwood forest. Over the course of the next several months, a nine-member citizen committee pondered with local, state, and federal water agencies the possibility of using river flows for ecological enhancement of the bosque. Eventually, the panel recommended that an interagency management plan be drawn up, and Congress appropriated funds to pay for it, along with related work including a five-year University of New Mexico/U.S. Fish & Wildlife Service overbank flooding project at Bosque del Apache National Wildlife Refuge, and studies of the river's flow regime. Soon, a letter of intent to cooperate in preparing a bosque management plan was signed by the Bureau of Reclamation, the Army Corps of Engineers, U.S. Fish & Wildlife Service, and the University of New Mexico.

Bosque del Apache Riparian Restoration Program

Bosque del Apache National Wildlife Refuge began its riparian restoration program in the late 1980s with a focus on research, monitoring, and the application of improved techniques for habitat restoration. The first restoration project included mechanical removal of dense saltcedar stands and the "pole planting" of approximately 3,000 cottonwoods on a forty-acre parcel. Groundwater and topographic maps plus analysis of soil characteristics determined planting locations. Since that time, techniques for site evaluation, exotic species removal, and reestablishment of native species have continually improved. The results are an increase in species diversity at restored sites, and more efficient use of staff and equipment. To date, Bosque del Apache has reestablished a native-dominated mosaic of dense forests and open grasslands on approximately 2,000 acres formerly occupied by monotypic stands of saltcedar.

Exotic species control techniques refined on the refuge include mechanical removal, chemical application of herbicide followed by controlled burns, and a combination of these two methods. Follow-up establishment of native species through planting or by mimicking the natural hydrograph has proven successful. Bosque del Apache serves as a center in the arid southwest for riparian research with cooperating universities. Studies on groundwater/surface water interaction, soil chemistry, evapotranspiration, aquatic habitat characteristics, species competition, and wildlife use provide Middle Rio Grande professionals with important information on ecosystem functions.

While fine-tuning methods and increasing the knowledge base to improve riparian restoration, Bosque del Apache National Wildlife Refuge has also contributed to the increased momentum for on-the-ground work throughout the Middle Rio Grande. Strong partnerships have been established that improve the chances for funding and implementing large-scale restoration. With the premise that the ecosystem benefits from improved communication, education, and on-the-ground examples of what is possible, the refuge has been host to diverse groups interested in finding solutions to water management and policy on the Rio Grande.

Figure 3. *John Taylor and Cliff Crawford at Bosque del Apache National Wildlife Refuge.* (Photo by Kim Eichhorst Mitchell)

Riparian restoration on the refuge was begun by the late John Taylor. Along with a dedicated field crew, he brought about some dramatic changes to the landscape in the Socorro valley. His desire to improve our knowledge of Rio Grande wildlife and diversity led to a better understanding of the ecosystem, and answered many questions about its physical and biological processes. He understood that work at the ecosystem level could bring about sustainable improvement. He also knew we need to be able to step back and let nature express itself. He was a strong believer in the adaptive approach to management and today, when you look out across Bosque del Apache National Wildlife Refuge, you see John's conversation with the land written clearly and beautifully in wetlands, grasslands, forests and savannas. (Gina DelloRusso, Refuge Ecologist, Bosque del Apache National Wildlife Refuge, 2004.)

As 1991 drew to a close, there seemed to be a general willingness on the part of the federal water agencies to try to accommodate river ecosystem needs. The Corps of Engineers proposed making larger floodwater releases from Cochiti Lake to inundate portions of bosque between the levees in the Middle Rio Grande and to aid in cottonwood regeneration. In a similar vein, thanks to the flow agreement that had been negotiated among landowners and resource agencies along the Rio Chama, the Bureau of Reclamation was providing optimum conditions there for the seasonal spawning of brown trout.

In early 1992, as part of the Bureau of Reclamation's "Middle Rio Grande Water Assessment," hydrologists at the New Mexico Bureau of Mines and Mineral Resources began assembling data from drilling records, borehole cuttings, core samples, and geophysical logs in the region from Cochiti to San Acacia. The mission was to construct a stratigraphic and tectonic framework of the Albuquerque Basin. It would be the first comprehensive reassessment of the region's aquifers since the 1960s.

That spring, the City of Albuquerque and the Middle Rio Grande Conservancy District (MRGCD) renewed the pilot Minimum Flow Agreement that had been worked out with the help of Rio Grande Joint Initiatives. Under a ten-year contract, 20,000 acre-feet of San Juan-Chama Project water owned by the city would be credited to the MRGCD annually. The water would be stored at El Vado, or released from Heron Reservoir at the MRGCD's request, and used to enhance river flows between Central Avenue in Albuquerque and Isleta Dam. Below Isleta, the water would become available for irrigation, and any excess would enter Elephant Butte Reservoir as 'natural flow,' helping to meet New Mexico's Rio Grande Compact delivery obligations.

Over the summer, as part of the City of Albuquerque's effort to assess its long-range water resources, an aerial survey of the Cochiti-to-San Acacia reach was undertaken in conjunction with the Bureau of Reclamation. The MRGCD eventually joined in cost-sharing the project. Taking advantage of emerging geographical information system technology, the Bureau of Reclamation also digitized land-use and vegetation types in the central Rio Grande valley, and produced the first definitive land use trend data using aerial photography from 1935 and other key years. Soon, the City of Albuquerque was mailing letters to the owners of large, mid-valley farms offering $1,200 per acre-foot for vested water rights. The proposition included a ten-year leaseback option to keep the rights in irrigation until they were needed by the city.

During the winter of 1992, University of New Mexico ichthyologists were studying a native fish called the Rio Grande silvery minnow. Once plentiful in 3,000 miles of river from the lower Rio Chama to the Gulf of Mexico, the minnow could now be found only in the 170 miles from Cochiti Dam to Elephant Butte. It wasn't a coincidence, researchers thought, that minnows and cottonwoods were both in trouble.

And so, the Middle Rio Grande's landmark year arrived.

1993

In January, the City of Albuquerque filed a complaint in Federal District Court against the U.S. Environmental Protection Agency (EPA) for approving water quality standards set by the Pueblo of Isleta without considering whether those criteria were "practically achievable." The standards, which were more stringent than those employed by the federal government, were the first in the nation to be proposed by a tribal government under a provision of the Clean Water Act of 1987, and Albuquerque, which had just applied for renewal of its National Pollutant Discharge Elimination System (NPDES) permit, had the dubious distinction of becoming the first discharger of effluent to have to comply. In particular, the city feared it would not be able to meet Isleta's requirement for arsenic, an element that occurs in naturally high concentrations in much of the West. Over the course of the next several months, Albuquerque, the Pueblo of Isleta, the EPA, and the New Mexico Environment Department negotiated an agreement that included studies of the occurrence and distribution of trace elements in the Rio Grande, and the city consented to additional treatment processes to reduce the amount of nitrate and ammonia it released into the river.

> *"When we bring attention to issues of contamination, non-Indians only want to talk about water rights." (Jim Hena, Chairman, All Indian Pueblo Council, to participants at the Middle Rio Grande Regional Water Planning Round Table, November 8, 1993.)*

Another federal environmental law was about to become a huge player in Middle Rio Grande water politics: the U.S. Fish & Wildlife Service was proposing to list the native silvery minnow as an endangered species. Public meetings were held in both Albuquerque and Socorro to ready the region for what was to come.

> *"At the required meetings, U.S. Fish & Wildlife asked, 'Is there anything we can do to prevent this listing?' We all looked at each other and said, 'No, this is the way it is.' We really didn't have any idea what the process would entail. How many species had ever been listed in the basin?" (Dick Kreiner, Chief of Reservoir Control Section, Albuquerque District, U.S. Army Corps of Engineers, personal communication, 2002.)*

August brought a second bombshell. Information gleaned from the Bureau of Mines' recent basin framework (Hawley and Hasse, 1992) and from a USGS groundwater flow model of the Albuquerque aquifer (Kernodle et al., 1986) showed there was far less quality groundwater available than previously believed, and worse, that vigorous recharge was only occurring in the immediate vicinity of the river and not in those areas being heavily pumped by the city. The *Albuquerque Journal* reported on August 25th that the city's wells were pumping four times as much groundwater as was being returned to the aquifer; that pumping had drawn down municipal wells in the valley more than 80 feet in the past 30 years; and that wells far from the river had been drawn down by as much as 140 feet.

Earlier that summer, the City of Albuquerque had filed an application with the Office of the State Engineer to increase its groundwater pumping from 135,000 to 155,000 acre-feet each year from the administratively-declared groundwater basin, and in nearby Rio Rancho, Intel Corporation had announced plans for a massive new fabrication unit that would require an additional 4,500 acre-feet of water. Now, armed with the new information on the basin's declining groundwater levels, Albuquerque argued that offset requirements contained in its original pumping permit were outdated, and that city-owned San Juan-Chama water intended for aquifer recharge had instead been augmenting Rio Grande surface flows. In preparation for deciding the

Albuquerque and Intel applications, State Engineer Eluid Martinez assembled a task force to look at possible changes to the administration of water in the Albuquerque basin. Public hearings on the issue were well attended indeed.

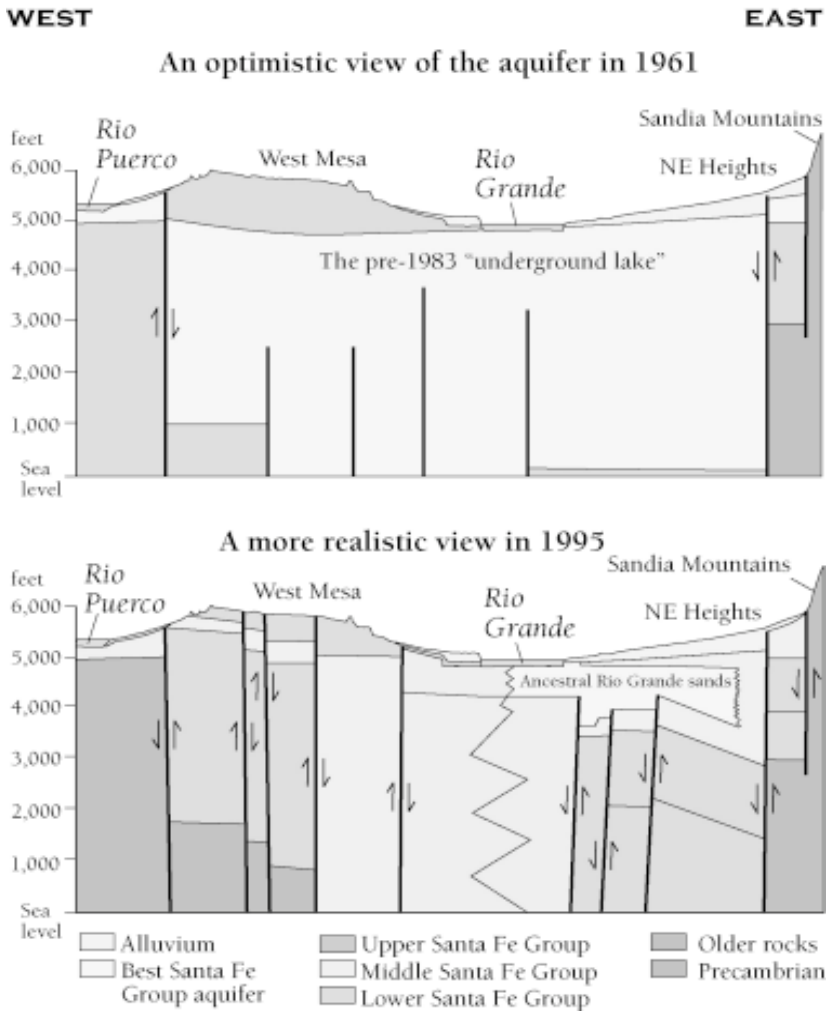


Figure 4. *Differing views of the Albuquerque aquifer, 1961 and 1995.* (Graphics courtsey of the New Mexico Bureau of Geology and Mineral Resources)

If the headaches that would haunt the Middle Rio Grande for the next decade had all surfaced in one prophetic year, some tools for dealing with so complex a picture were also at hand. The state was inching toward a water conservation program and had launched a three-year study cost-shared by the Interstate Stream Commission, the Bureau of Reclamation, and the U.S. Army Corps of Engineers to collect fresh data about New Mexico's water assets. A basin consortium had been formed, later to be known as the Rio Grande/ Rio Bravo Basin Coalition, with the goal of promoting resource sustainability and improving water management across state and international borders. The New Mexico Environmental Law Center issued a report*, "Living Within Our Means: A Management Policy for New Mexico in the 21st Century*," (Bokum, et al., 1992) which urged improvements to the state water code and to the processes of public notice, public input, and public welfare. And belatedly, New Mexico's five-year-old regional water planning program was gaining ground as an arena where resource managers, technical experts, politicians, and citizens could have a hand in

shaping future water policy. Previously, exchanges about water operations had taken place among a handful of governmental agencies. Now those policy discussions were beginning to occur at the local level.

'**P**lan' was, in fact, the word of the day. The Middle Rio Grande Council of Governments had published a four-volume set of policy guidelines several years earlier (Wilson, 1990) but the new groundwater flow model invalidated many of the work's assumptions. Now there were advocates for creating a true water plan to which the lay public had increased input. Residents had already earned a place alongside professional planners in designing the Albuquerque/Bernalillo County Groundwater Protection Policy and Action Plan (Albuquerque/Bernalillo County, 1993). City and county officials and a group of citizen volunteers had spent three years on the plan, which instituted changes regarding the permitting and construction of septic systems, prohibited businesses that handled hazardous materials and/or wastes in areas with vulnerable shallow groundwater, and provided for better regulation of a variety of underground storage tanks that were sources for groundwater pollution.

Other germane programs were also being drafted and adopted. Albuquerque's Parks and General Services Department generated a Rank Two Facility Plan (City of Albuquerque, 1993) for grooming and managing twenty-two miles of bosque within Rio Grande Valley State Park, and the fee-simple owners of that same expanse of riparian forest—the seventy-year-old Middle Rio Grande Conservancy District—produced its first-ever water policies plan (DuMars and Nunn, 1993). The latter included suggestions for using 'surplus water' that would echo in the debates to come. The MRGCD hoped to bank any unused rights so that they might be "leased to municipalities to offset the effects of deep well pumping, left in the river to maintain minimum flows for diluting municipal wastewater, or used to create favorable habitat in the bosque and district drains."

> *"Substance and process can't be separated in public decisions. How we decide as a people will determine what we decide, especially about how we relate to our land and water. When part of the community decides in isolation how we will use water—engineers alone, or lawyers alone, urbanites alone, or farmers alone—important facts about the values of the rest of the community are neglected... The process of making public water policy is not a matter of deciding whether environmentalists or irrigators are right. It is discovering what each of us—environmentalists and cities and Native Americans and acequias—need to make the central values of our communities a reality." (Regional Water Planning Dialogue, Nunn, 1993.)*

And then, in September of that signpost year, the Middle Rio Grande was given a primer for maintaining its considerable natural resource assets. Researched and written by an interagency team of biologists from the University of New Mexico, the Army Corps of Engineers, the Bureau of Reclamation, and the U.S. Fish & Wildlife Service, the document offered a holistic point of view and twenty-one recommendations aimed at achieving integrated management of the central Rio Grande and its floodplain. In recognition of the biologic, hydrologic, and geomorphologic linkages crucial to riparian health, the report's authors added a cardinal word to the title of the *Middle Rio Grande Bosque Biological Management Plan*. That word was 'ecosystem.'

> *"I don't think many had a sense that the Bosque Biological Management Plan was going to be the basis for so much. It established the goals and objectives for at least twenty years worth of work. People go back to it time and time again because of the things that were laid out in a broad context." (Dick Kreiner, U.S. Army Corps of Engineers, personal communication, 2002.)*

1994

At a January public forum in Albuquerque, author and conservationist William deBuys, who had shepherded Senator Pete Domenici's original Rio Grande Bosque Conservation Committee, predicted that the *Bosque Biological Management Plan* would become a standard for putting the river ecosystem first, and for dissolving a multitude of institutional boundaries. State legislators, it seemed, were listening. They named a task force to design a management structure that could implement elements of the new plan. After a series of meetings with the public and with pertinent agencies and governments throughout the region, the task force recommended formation of a formal bosque coordinating council, with representatives from "every existing governmental entity with significant jurisdiction." The council was expected to adopt a set of bosque management principles, submit yearly reports on the state of the riparian forest, serve as a clearinghouse for information and a liaison between the public and management agencies, and solicit and administer grants for work in the bosque. But the proposed structure ran aground over issues of bosque ownership, the feasibility of so large a council, and its lack of real authority.

Coordinating council or not, money for bosque restoration was beginning to come in with the continued advocacy of Senator Domenici. Congress appropriated an initial $600,000 to the U.S. Fish & Wildlife Service for bosque work in the Middle Rio Grande. In the coming years, annual appropriations to support implementation of the *Bosque Biological Management Plan* would be dispersed by the Middle Rio Grande Bosque Initiative (see Appendix A and B), and administered by a full-time Middle Rio Grande Bosque Coordinator, a post that would first be filled in the spring of 1995.

On other waterfronts, the MRGCD was trying to meet a January deadline imposed by the state legislature for completing its new geographic information system. After two years of work, 126 out of a total of 210 MRGCD land classification maps had been digitized. Their accuracy was said to be ninety-eight percent, subject to the quality of the originals and the information obtained from several counties and Bureau of Reclamation land reclassification data. Aerial photos taken by the Bureau of Reclamation in 1992 were used to create an irrigated/non-irrigated layer for the database, but according to the system's project manager, confirmation would eventually need to be made on some 60,000 parcels of land using everything from ditch rider logs to satellite data (MRGCD Board of Directors' meeting minutes, January 11, 1994).

The Corps of Engineers was studying ways to reduce the cost of the $12 million Corrales Unit Levee Project. One suggestion was to take the topsoil, grass, and tree roots that could not be used in rebuilding the levee, and rather than haul them to the Rio Rancho landfill, turn them into 'top dressing' for seeding the levee with native grasses once construction was complete. Environmental-minded residents of Corrales, however, objected to the "deposition of anything in the bosque." (Chris Schaeffer, Corps of Engineers presentation to the MRGCD Board, January 11, 1994.)

That spring, State Engineer Eluid Martinez declared a 120-day moratorium on the longtime policy of 'dedication,' by which a developer could delay obtaining the surface water rights necessary to offset groundwater pumping in the Albuquerque basin. A State Engineer task force assembled the previous fall had recommended that land developers, corporations, and municipalities applying for permits to pump groundwater be required to purchase offset rights prior to pumping. For years, such permits had been issued with little but a promise to acquire and retire surface rights in the future, a practice that had seriously aggravated the gap between paper rights and wet water in the fully appropriated basin.

At about the same time, Martinez also approved Intel's application to pump additional water. The giant corporation would be allowed to drill three 2,000-foot wells to pump 2.9 million gallons per day from the aquifer.

Two conditions accompanied the permit: Intel was charged with monitoring its pumping so as not to adversely affect groundwater levels in shallow wells within a two-mile radius of the manufacturing plant; and surface rights would have to be acquired to offset any impacts on the flow of the Rio Grande.

As promised, the summer of 1994 also saw the official listing of the Rio Grande silvery minnow (Federal Register, 1994.) The listing was accompanied by one significant Endangered Species Act policy change: in July, the Federal Register announced that no longer would membership on endangered species recovery teams be limited to U.S. Fish & Wildlife Service personnel, nor to those with biological expertise. The Rio Grande Silvery Minnow Recovery Team would be the first in the nation to involve actual 'stakeholders.'

To underscore the year's momentous happenings relative to water in the Middle Rio Grande, the New Mexico Water Resources Research Institute (WRRI) held its annual conference in November on "The Water Future of Albuquerque and the Middle Rio Grande Basin." More than a few quotes from the proceedings (Ortega-Klett, 1994) remain applicable to this day:

> *"Can a water resource that is rigidly fixed support perpetual population growth? When posed in these absolute terms, the answer is obvious and unequivocal: No! So, avoiding the bungee effect —avoiding having to pay back 'wet water' after we have overconsumed—is a compelling issue that needs our attention now. Later might be stretching it too much." (Hydrologist Frank Titus, State Engineer's Technical Advisory Committee for the Middle Rio Grande, p. 389.)*

> *"Conservation of highly altered river systems such as the Rio Grande calls for a realistic look at management alternatives. Given the changes in the Middle Rio Grande Valley that were caused in this century by regulation and other forces (including colonization by introduced woody plant species), a return to the exact pre-settlement condition is clearly impractical. Under the circumstances, we therefore advocate the reestablishment of basic riverine-riparian functioning rather than the 'saving' of a bosque that is itself an artifact of civilization. We propose that sustaining ecosystem integrity, in the form of carefully planned partial restoration, is the only reasonable alternative to irreversible ecosystem change. The latter, we predict, will be the eventual outcome of 'status quo management' occurring with the unlimited growth of the basin's human population and its continued high rates of water consumption... The essential elements of partial restoration are (1) carefully regulated seasonal overbank flooding or its simulated equivalent, (2) riparian forest management leading to improved habitat diversity, (3) creation of diverse wetlands inside and outside the present levee system, and (4) a sustained program of monitoring, research, and education." (Cliff Crawford, University of New Mexico Research Professor in Biology and principal author of the Bosque Biological Management Plan, p. 103.)*

> *"Virtually every state has concluded that riparian system values exist outside traditional uses of water. In our area, the bosque will demand some quantity of water over certain periods of time to maintain the riverine system. So separate from federal mandates are public welfare mandates. As the public will redefines water's value, it will have a direct impact on the ability to take groundwater in storage, because groundwater cannot be used if the amount taken*

cannot be offset with water from the stream. If the groundwater well creates an effect on the bosque, or on the silvery minnow, or on downstream compact obligations, Mexican Treaty obligations, or on the senior rights of the Indian Tribes, you cannot take the water. That is the practical reality from the legal standpoint of conjunctive management." (Charles T. DuMars, University of New Mexico School of Law, p. 121.)

"Of the nine water-rights adjudication cases in the state in which Indian rights are a party, seven involve tributaries of the Rio Grande... One that has not been filed is the 'Middle Rio Grande Case' which includes the six pueblos recognized as having paramount rights because these lands were irrigated prior to formation of the MRGCD. The pueblos have rights to irrigate 11,948 acres. The potential claim and adjudication is for rights to more than those acres. That highlights the uncertainty in this valley of how many acres the pueblos have a right to irrigate. Given this uncertainty, I think the selling, leasing, and exchanging of water in the middle valley should be done with extreme caution…" (John Cawley, Bureau of Indian Affairs, p. 404.)

"The last possibility for defining 'public welfare' is one that the State Engineer has several times suggested he prefers...that he will consider in the public welfare analysis of every [water right] application what is said about public welfare in the regional water plans... [This] puts the definition of public welfare policy on the shoulders of the public…" (Martha Franks, State Engineer's Rio Grande Task Force, p. 409.)

1995

The year began with a shuffling of the cast of characters. In Santa Fe, there was a new Governor, Gary Johnson, and a new State Engineer, Tom Turney, who promised a more integrated approach to water management wherein quality, quantity, agricultural, municipal, environmental, and economic issues would all be considered as a whole. Turney also announced a huge effort to transfer some 183,000 State Engineer Office files to a state-of-the-art database called W.A.T.E.R.S., giving the public unprecedented access to water right declaration and transfer information, well reports, historic documents, digitized hydrographic survey maps, and hearing schedules.

Just across the hall from Turney in the venerable Bataan Building, former City of Albuquerque water utilities manager Norman Gaume was the new Interstate Stream Commission engineer. Among other things, Gaume would drive a hard bargain with regional water planners over their divergent products, and would also design the initial 'framework' for a state water plan.

On the federal level, Colonel Lloyd (Steve) Wagner arrived in the spring of 1995 to head the Albuquerque District of the Corps of Engineers, one of several leaders whose style would invoke stronger interagency cooperation. Another, Garry Rowe, had already taken up the reins of the Bureau of Reclamation's Albuquerque Area Office. A third, Jeff Whitney, had signed on with the U.S. Fish & Wildlife Service as the much-anticipated Bosque Coordinator who would oversee Middle Rio Grande "preservation initiatives" derived from the *Bosque Biological Management Plan*.

As promised, the U.S. Fish & Wildlife Service granted voting seats on the Rio Grande Silvery Minnow Recovery Team to the New Mexico-based environmental group Amigos Bravos, the Bureau of Reclamation, the Corps of Engineers, the City of Albuquerque, New Mexico's Interstate Stream Commission, the Middle Rio Grande Conservancy District, the New Mexico Department of Game and Fish, the New Mexico/Texas Water Commission, the Rio Grande Compact Commission, Texas Parks and Wildlife Department, and the Texas Water Commission (now the Texas Water Development Board). Non-federal entities would be entitled to nominate a biologist to sit on a subcommittee for the science team. U.S. Fish & Wildlife Deputy Director John Rodgers called the arrangement a "prototype for future endangered species issues in the mid-valley." Never, he told an audience of MRGCD directors and constituents on February 13, would stakeholders have to "fight this fight again."

With budget concerns in the forefront, a first attempt at state legislation to create an official 'bosque advisory council' received the Governor's veto that spring, and many who would have served as members of the proposed delegation realized that a volunteer effort was needed if implementation of the *Bosque Biological Management Plan* was to proceed. In May, the newly appointed Middle Rio Grande Bosque Coordinator invited researchers, water managers, and bosque advocates to Sevilleta National Wildlife Refuge for a two-day brainstorming session. It was understood that holistic river management was going to require some means of regular communication, not only about the state of the ecosystem, but also in regard to the growing array of related projects. Contrary to the casual perception that work on the Rio Grande was standing still, a startling number of activities meeting the intent of the *Bosque Biological Management Plan* were underway. The Corps of Engineers, the Bureau of Reclamation, U.S. Fish & Wildlife Service, USGS, the New Mexico Interstate Stream Commission, the City of Albuquerque, the MRGCD, the state's foremost universities, Bosque del Apache National Wildlife Refuge, the Sevilleta Long Term Ecological Research Center, Sandia National Labs, and a host of non-governmental groups were collaborating in scores of combinations. It was clear that plenty was underway, even in the absence of a coordinating council. Attendees at the Sevilleta retreat assessed the management plan's twenty-one recommendations and singled out priorities for the near future. These included establishing an overall bosque monitoring program and a central repository for the data; supporting local interest groups involved in riparian restoration; updating vegetation classification and mapping done in the early 1980s and identifying sites for revegetation; studying the potential for relocating the levee and Low Flow Conveyance Channel south of Bosque del Apache to expand the floodplain; and finding a means of participating in the distribution of Bosque Initiative funds allocated to U.S. Fish & Wildlife Service for bosque improvement.

> *"Harness up and we'll pull in the same direction." (Middle Rio Grande Bosque Coordinator Jeff Whitney to Sevilleta retreat participants, May, 1995.)*

The ideas that surfaced at the Sevilleta retreat were a remarkable augury of things to come, but the symposium's real accomplishment was the formation of the Bosque Improvement Group (BIG). Conceived as an inclusive think tank open to anyone who wanted to show up, BIG quickly became a workhorse for the Middle Rio Grande Bosque Initiative, the long-term, Congressionally supported, interagency ecosystem management effort begun by Senator Domenici in 1991. BIG's ad hoc members still convene annually to review prospective proposals and to distribute federal funds to an impressive array of habitat enhancement, research, monitoring, and public outreach projects. (A matrix of the projects funded through BIG and the Bosque Initiative since 1995 is included in Appendix B; for additional information on specific projects, visit the Middle Rio Grande Bosque Initiative website at *http://mrgbi.fws.gov*.)

The Bosque Hydrology Group

An interagency team concentrating on the "morphological realities" of the Rio Grande, the Bosque Hydrology Group (BHG) was established as a Middle Rio Grande Bosque Initiative work group and is funded through the Bosque Initiative/BIG.. Its initial goal was to coordinate hydrologic and bio-hydrologic information, but the focus subsequently became physical restoration of the river's hydrologic processes. Members include academics, agency and tribal personnel, and others directly involved with or interested in collecting and analyzing information on the health of the bosque and river's flow regime.

The Bosque Hydrology Group has been an avenue for "cross-pollination" and has resulted in a conceptual framework for restoration within the existing system. The basic tenets of that framework include removing constraints such as jetty jacks along suitable reaches of river bank; thinning the riparian forest; reconnecting the river with its floodplain; and improving or naturalizing to whatever extent possible the hydrograph out of Cochiti.

To discover where such work can most advantageously be done, BHG cooperated with the Bureau of Reclamation, the Corps of Engineers, U.S. Fish & Wildlife Service, the New Mexico Interstate Stream Commission, and consultants from Tetra Tech, Inc. to develop a two-dimensional, flood routing computer model called FLO 2D, which can be used to predict the extent of overbank flooding in a mainstem river system. Data obtained from some 400 cross-sections between Cochiti and Elephant Butte Reservoir, and from agency databases and Light Detection and Ranging (LIDAR) imaging, are built into the model to create a system with more than 29,000 grid elements. Once evapotranspiration data is added, the model will be able to compute all losses off the free channel and floodplain, with the exception of infiltration to groundwater. The model will be used to predict inundation areas and water surface elevation, and to evaluate possible restoration sites and impacts. FLO 2D modeling began with the Isleta and San Antonio-to-San Marcial reaches of the Rio Grande.

Bosque Hydrology Group members are involved in numerous projects including the construction of a hydrologic data directory for the Middle Rio Grande; a study of the relationship between soil texture, geomorphic features, and salinity levels in floodplain soils that affect the potential for revegetation and habitat characteristics; research into the bio-hydrology of floodplain forests; developing a water use budget for Bosque del Apache National Wildlife Refuge's saltcedar removal and cottonwood/willow regeneration efforts; geomorphic and hydrologic data collection and analysis of the San Acacia-to-Elephant Butte reach; computer modeling of fish habitat; analysis of flow records for the San Acacia-to-Elephant Butte reach for the Interstate Stream Commission; and the analysis of flow, seepage, and water quality information for the entire Middle Rio Grande. Using information that is now coming from evapotranspiration research, BHG is also compiling water budgets for the bosque in various reaches.

BHG holds up to three mini-symposiums a year, and maintains a web page (http://bhg.fws.gov) that contains feature articles, a photo database, updates of ongoing research projects, and contact information. (Paul Tashjian, U.S. Fish & Wildlife Service hydrologist and Chairman of the Bosque Hydrology Group, 2003.)

Another enduring product of the Bosque Initiative is a loose-leaf workbook called the *Bosque Education Guide*, (Stuever et al., 1995, and Morris et al., 2003) a treasury of information, experiments, activities, and thought-provoking questions aimed at expanding students' and citizens' understanding of and appreciation for the riparian forest of the Middle Rio Grande. Created by educators, scientists and bosque advocates, the *Guide* serves as a basis for classroom and field studies from kindergarten to high school, and has gently widened the horizons of numerous adults as well, through programs at the Rio Grande Nature Center and the New Mexico Museum of Natural History. Through its pages and accompanying training workshops, local teachers are given grounding in geology, hydrology, biology and history, which together define the Rio Grande bosque.

In June, the Middle Rio Grande Conservancy District obtained grant funding from the New Mexico Interstate Stream Commission for the local sponsor share of the $11.6 million Corrales Levee Project, "cornerstone" of the Corps of Engineers' plan to upgrade critical sections of the Rio Grande levee. It would be the first mid-Rio Grande flood control project since 1971.

Another effort that would have long-reaching effects on water management in the Middle Rio Grande was also born in 1995. At an initial meeting between the Bureau of Reclamation's Albuquerque Office chief Garry Rowe and Col. Steve Wagner of the Albuquerque District Corps of Engineers, Wagner paraphrased what he had recently learned about his new assignment: "The Corps handles the 'too much water' scenario, and Reclamation handles the 'not enough water' scenario. Seems like we ought to be working very closely together." (Ret. Col. Steve Wagner, personal communication, 2002.)

Yet between the two agencies lay a technological communication gulf that made projecting the federal operation of the basin exceedingly difficult. The Bureau of Reclamation's Albuquerque Office had spreadsheets for Heron and El Vado Reservoirs. The Corps had a river and reservoir simulation model called HEC-5 that it used for Abiquiu, Cochiti, and Jemez Canyon Reservoirs. Reclamation's El Paso Office had another set of spreadsheets for Elephant Butte and Caballo Reservoirs. What was needed was a unified water operations model into which Reclamation, the Corps, and other entities could all enter data.

By the following year, a Memorandum of Understanding would be signed by the Bureau of Reclamation, the Corps, U.S. Fish & Wildlife, USGS, and the Bureau of Indian Affairs to cooperate in creating such an instrument. The International Boundary and Water Commission soon joined the project as well, and work on the Upper Rio Grande Water Operations Model (URGWOM) began.

Amid the anxiety engendered by silvery minnows and river restoration, URGWOM represented a patch of safe ground on which those involved in stickier issues could meet and agree. Not to say that developing the model was a simple matter. It took nearly two years to select and test the software that would be used—a program called RiverWare developed by CADSWES, an interdisciplinary research center at the University of Colorado at Boulder. The program was subjected to rigorous review and modification for use in the Upper Rio Grande Basin. Ultimately, it would account for inflows and outflows to the system; storage levels at Heron, Abiquiu, Cochiti, Jemez Canyon, Elephant Butte and Caballo Reservoirs; floodwater; irrigation diversions and return flows; San Juan-Chama diversions; and interstate compact and treaty flows on their way to downstream users. Aside from providing a testing ground for a variety of management approaches and scenarios, the model had the potential for becoming the common language among a myriad of agencies with missions on the Rio Grande.

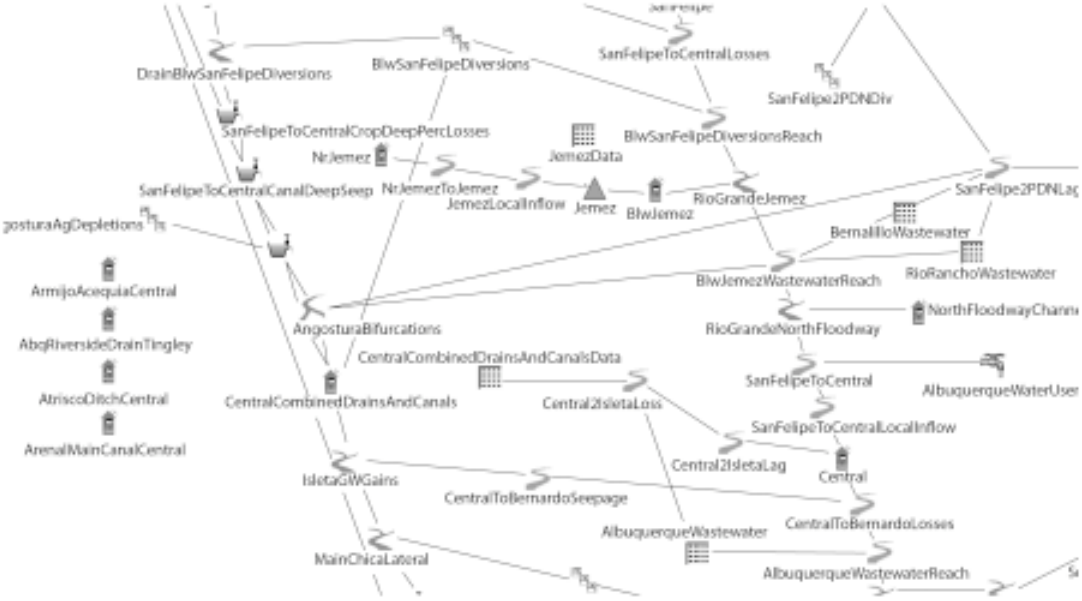


Figure 5. *An example of the Upper Rio Grande Water Operations Model in schematic form. The complete schematic is presented in PDF format on the compact disk in the pocket of this document, and is also accessible on the Corps of Engineer's website.* (Diagram courtesy of the U.S. Army Corps of Engineers)

If projects such as URGWOM were finally placing due emphasis on 'wet water,' the common currency was still paper. In November, the MRGCD established an internal water bank, wherein excess rights could be deposited for short-term lease to other users. By state law, idle conservancy or irrigation district water rights cannot be forfeited, but there were increasing nuances that such might not always be the case. "In an age of litigation," MRGCD water attorney Charles T. DuMars warned stakeholders in a series of public meetings on the proposed policy, "unused is unwise." Unfortunately, before individually owned rights could be accepted for deposit in the new bank, the MRGCD required a certification of validity from the Office of the State Engineer, and the only way to obtain such a document was to offer the rights for sale or transfer. Limited transactions were conducted using the MRGCD's 'permitted' rights, but as those were junior to the more valuable pre-1907s, few took advantage of the conservancy's water savings and loan.

On a more cosmopolitan note that October, a celebration in honor of the river and its impact on human lives was inaugurated by the Rio Grande / Rio Bravo Basin Coalition. "Dia del Rio" would become an annual event in basin communities from Colorado to Mexico, coaxing hundreds of citizens down to the often-unfamiliar shore of their local river to pick up litter, plant native vegetation, and offer tribute to the life-giving flow.

Some months earlier, the City of Albuquerque had commissioned a report, "The Value of Water," (Brown et al., 1996) to point the way toward prudent resource management and to help determine the trade-offs involved in adopting one strategy over another. The report, which would be released soon after the New Year, offered the following key observations:

- Albuquerque citizens need to make a fundamental change in how they see groundwater underlying the city. The aquifer cannot be, perpetually, a sole source of water supply. It can, however, be a reserve for the present and for the future.

- An inclusive public process is needed to determine acceptable trade-offs among urban, agricultural and riparian water users.

- Albuquerque and other Middle Valley water providers should send accurate price signals to water users about the economic value of water that reflect those trade-offs.

"When water becomes scarce, it acquires economic value, often reflected in price, but always reflected in trade-offs." ("The Value of Water," Brown et al., 1996.)

1996

'Ninety-six was the first drought year in nearly twenty. The silvery minnow had been listed two summers before but conditions hadn't been so dire that its endangered status dominated water operations. Now, a meager snow pack made it almost certain that irrigation delivery, especially below San Acacia Dam where the majority of the remaining minnow population was found, would have to be curtailed. By mid-April, diversions in the Belen and Socorro Divisions of the Middle Rio Grande Conservancy District had dried up portions of the river channel, dooming thousands of silvery minnows. The U.S. Fish & Wildlife Service and the Bureau of Reclamation prevailed upon the MRGCD to maintain an emergency flow of 100 cfs below San Acacia Dam until something could be worked out among the agencies to avoid a further 'take' of minnows. Before the month was over, however, the Southwest Center for Biological Diversity had filed a 60-day Notice of Intent to Sue. Target agencies were the MRGCD, the New Mexico Office of the State Engineer, U.S. Fish & Wildlife Service, the Bureau of Reclamation, and the U.S. Secretary of the Interior. The charge was violation of Sections Seven and Nine of the Endangered Species Act.

"How do we get farmers listed as an Endangered Species?" (Socorro landowner Larry Whitefield, MRGCD board meeting, April 23, 1996.)

The Silvery Minnow Recovery Team was already at work on recommendations to provide enough water for the fish. On May 20, sufficient flow for a spawn of minnows was created using a 'spike' of San Juan-Chama water owned by the cities of Albuquerque and Taos. In the first of many verbal games, the water that would actually reach the fish was exchanged on paper and labeled "Rio Grande" to avoid violating San Juan-Chama Project contracts which do not list species rescue as a condoned beneficial use. Since loss rates in the parched riverbed exceeded those of an already wetted irrigation system, the water was transported through MRGCD ditches to ensure an adequate flow at San Acacia.

With the spike successful, the recovery team then concentrated on how to furnish a steady minimum of water to the critical reach. Daily conference calls were occurring between the U.S. Fish & Wildlife Service, the Corps of Engineers, the Bureau of Reclamation, and the MRGCD to set up the required flows, but

obtaining the necessary water was another challenge altogether. New Mexico remained the only state in the union without an instream flow law, and many feared that water bequeathed to the river represented a water right in legal jeopardy.

> *"In New Mexico, a water right is established when water is diverted. If rights are obtained under the law, there is no specified hierarchy of uses for that water. Providing habitat for fish could be considered just as beneficial a use as irrigation. Until the state adopts a provision for instream flow, the point-of-diversion problem might best be approached by a mechanism such as the MRGCD's proposed water bank." (Commissioner Eluid Martinez, Bureau of Reclamation, to MRGCD Board, April, 1996.)*

With its farmers up in arms over impending species litigation, MRGCD officials pressed the Bureau of Reclamation do something. In response, Reclamation, Corps of Engineers, U.S. Fish & Wildlife Service, New Mexico Interstate Stream Commission, MRGCD, and City of Albuquerque personnel drafted a strategy paper to "outline alternative courses" for getting water to critical reaches of the river to preserve the endangered fish. Laboriously negotiated by "working guys" and eventually endorsed by managers of their respective agencies, the ensuing "Water Management Strategy for the Middle Rio Grande Valley," or 'White Paper' (Whitney, et al., 1996) testified to the field expediency that prevailed in the summer of 1996. The introduction says, "...agencies and entities directly involved in water operations for the middle valley largely succeeded in satisfying the water needs of the silvery minnow and water users, including district irrigators. This success was due to [the MRGCD] operating its system to allow native Rio Grande water to remain in the river, undiverted, for the minnow, and the City of Albuquerque and other entities making some of their San Juan-Chama Project water available to the District for use by irrigators at no cost to the water users in the valley." It was acknowledged, however, that San Juan-Chama water might not be obtainable in the future, and that managers would therefore have to share responsibilities to satisfy basin water users, including the minnow, beyond 1997. Noting that "actions taken must be legal, economically feasible, politically acceptable, and implementable in a timely manner," the list of alternatives included water acquisition from willing sellers; conjunctive use of ground and surface water; increased capability for upstream storage of native water at Heron, Abiquiu, Cochiti, and Jemez Reservoirs; increased water-use efficiency; and improved water rights administration via metering and monitoring, with or without adjudication. The White Paper recommended using any combination of the alternatives that could readily be accomplished while pursuing the institutional changes necessary to address the issue in the long term. It also urged interagency cooperation, and the delegation of staff to work on development and implementation of an action plan.

> *"The value of the White Paper cannot be underestimated. It is the first such document endorsed by a group representing diverse institutional interests that begins to address the wide spectrum of middle Rio Grande water management challenges we collectively must resolve. As we are all aware, this is but another step in a long process." (Garry Rowe, Director, Albuquerque Office, U.S. Bureau of Reclamation, address to the MRGCD Board of Directors, November, 1996.)*

> *"You'd have thought we were negotiating peace in Bosnia..." (Rob Leutheuser, Albuquerque Office, U.S. Bureau of Reclamation, personal communication, November 26, 1996.)*

A collective resolution to water problems was being sought in the drainage of the Rio Jemez, too. With the worsening drought, federal attorneys representing the Pueblos of Jemez, Zia, and Santa Ana were preparing to make a 'call' on the water of the Rio Jemez in the form of an injunction that would curtail use by junior right holders such as the villages of San Ysidro, Cañon, Jemez Springs, La Cueva, Ponderosa, and Gilman. After sixteen years of adjudication proceedings in the basin, tribal and non-tribal residents had grown used to thinking of each other as opponents, but now they realized that a priority call by the tribes would inflict real hardship on their non-Indian neighbors. To stave off the proposed federal injunction, an old priority call agreement between the Pueblo of Zia and the community of San Ysidro was used as a model for a new contract to share water among users of the Rio Jemez in times of shortage. The agreement acknowledged the seniority of pueblo water rights, but outlined a number of weekly rotation schedules that could be enacted to meet non-Indian water needs based on the amount of water available in a given irrigation season. Stakeholders also agreed to work together to secure funding for improving inefficient irrigation facilities, and to address the need for upstream storage. The agreement earned the Court's approval in the Rio Jemez adjudication, and it marks the first time in U.S. history that water users on a stream system have worked out a priority call process for themselves. ("*Healing the Jemez*," New Mexico Water Dialogue, Robert, 1996.)

In midsummer, the Bureau of Reclamation released the findings of a five-year, multicomponent series of interagency studies on water in the Middle Rio Grande. In conjunction with U.S.Geological Survey's (USGS) groundwater flow model of the Albuquerque Basin, the *Middle Rio Grande Water Assessment* (U.S.B.R., 1997) analyzed past impacts to the area's groundwater, and modeled likely effects to the system resulting from proposed water management changes. The report's banner headline was that fifty percent of the recharge to the Albuquerque Basin—about 31,000 acre-feet of water each year—was coming from canal seepage and flood irrigation in the MRGCD. Unfortunately, the report noted, the number of irrigated acres in the middle valley had dropped from 20,400 in the 1950s to about 11,500 acres in 1993, representing a loss of 6,000 acre-feet of recharge annually. Should urbanization trends continue, the authors concluded, a dependable means of aquifer recharge could be lost, with severe consequences. City, county, and state governments were encouraged to consider incentives to preserve irrigated acreage, and the MRGCD's irrigation and drainage facilities were identified as a possible mechanism for enhancing aquifer recharge.

Also that summer, an important outreach program was initiated on behalf of the Rio Grande bosque. With funding from the National Science Foundation and the Bosque Initiative, the University of New Mexico's Biology Department and the private Bosque School in northwest Albuquerque began collecting long-term ecological data at a number of sites along the river. A high-value, low-cost answer to the need for a monitoring program and central repository for data, the Bosque Ecosystem Monitoring Program (BEMP) set about harnessing the energy of citizen volunteers—predominantly students from kindergarten through high school, and their teachers—to monitor key variables reflecting bosque ecosystem structure, functioning, and biodiversity at sites with different flooding histories, and to track environmental trends in the bosque. To date, some forty schools in six counties have participated in BEMP, and a three-hour course at the University of New Mexico allows college students to earn credits in biology research and environmental education while providing interns for the program. Data on groundwater levels, precipitation, plant productivity, and insect activity are regularly collected by classrooms in the field, while the monitoring of more complex variables such as vegetative cover, and air and soil temperature is contracted out to individual researchers. The data is analyzed and interpreted to provide an overall fingerprint of a site's health, and the information is made available to all resource management agencies. Both the City of Albuquerque Open Space Division and the Middle Rio Grande Conservancy District have used BEMP rainfall data to help determine when to open or close the bosque to the public during periods of high fire danger, and BEMP data contributed to a USGS / Corps of Engineers model of groundwater flow and seepage in the middle valley. BEMP maintains sites at San Juan and Santa Ana Pueblos; at Alameda, Savannah (Bosque School), the Rio Grande Nature Center, the National Hispanic Cultural Center

of New Mexico, and Harrison Middle School in Albuquerque; at Los Lunas and Belen; at the Sevilleta National Wildlife Refuge; and at the Socorro Nature Area in Lemitar. Requests to participate in the program are on the increase, and BEMP has expanded to allow onetime classroom visits to bosque sites to observe how data is collected and processed.

> *"BEMP is not an advocacy organization. Rather, it monitors and interprets environmental change in the Middle Rio Grande bosque. Without a context, that kind of work can be pretty sterile, so we depend on various speakers from the water resources arena, University of New Mexico biology grad students, and the BEMP staff, to provide that context. We're informing young people about what is happening to the ecosystem of which the bosque is a part, and we emphasize that they think critically about the overall issue." (Cliff Crawford, BEMP Director, personal communication, 2003)*

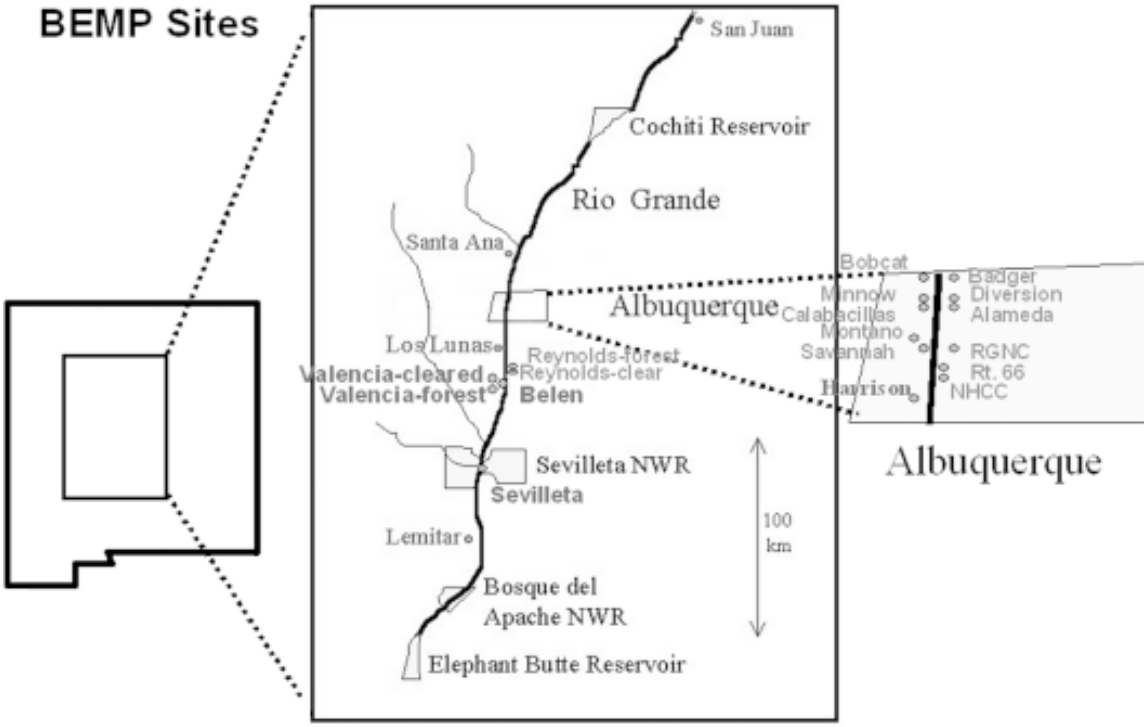


Figure 6. *Bosque Ecosystem Monitoring Program sites in the Middle the Rio Grande*. (Map courtesy of BEMP)

1997

In another attempt to legislate a coordinating council for the Rio Grande bosque, New Mexico Senator Dede Feldman sponsored the Bosque Advisory Act, and although it received the support of many of the affected agencies, the proposal once again earned a budget-minded Governor's veto. The legislative session also produced the Aquifer Storage and Recovery Act, authorizing creation of a groundwater reservoir for the City of Albuquerque.

Socorro's Save Our Bosque Task Force

Lack of an official coordinating entity for bosque rehabilitation had not stopped residents of Socorro County from addressing a host of environmental headaches along their stretch of the Rio Grande. In 1994, a broad spectrum of citizens and agencies had formed a nonprofit organization called the Socorro Save Our Bosque Task Force, and set about mitigating human impacts to the bosque. Nineteen of the twenty-five river miles from San Acacia to Bosque del Apache National Wildlife Refuge were relieved of 10,000 cubic yards of trash in a marathon of cleanups over a three-year period. The value of what lay underneath all that debris soon became clear to everyone, and the group's focus began to shift: how could they protect the neglected riparian woodland from the indifference bred by so many generations of illegal dumping, burning, and tree-cutting? The answer, they decided, was to make respect for the river and protection of its fringe of green a permanent part of Socorro's ideology.

By 1997, the crusaders had completed a Memorandum of Understanding between the City and County of Socorro, the Socorro Chamber of Commerce, the New Mexico Department of Game & Fish, New Mexico State Forestry, the New Mexico State Police, the Middle Rio Grande Conservancy District, and the U.S. Department of the Interior, including U.S. Fish & Wildlife Service, the Bureau of Reclamation, and the Bureau of Land Management, to enhance riparian habitat and increase environmental awareness while continuing to support historical recreational uses of the Rio Grande and its bosque.

With an initial grant of $15,000 from the Bosque Initiative/BIG, and $35,000 from the state's Youth Conservation Corps Commission, the Socorro Save Our Bosque Task Force hired a crew of youngsters and began construction of an Environmental Education and Nature Center in the now-spotless bosque near Lemitar. The final result proved not only a delight to countless visitors, but also a positive reinforcement to those that had volunteered time, donated materials, and moved administrative mountains to get the job done.

Next the group turned its attention to an old borrow pit, remnant of construction in the 1950s of the nearby Low Flow Conveyance Channel. Soon the old eyesore had become a lively pond and wetland, and Socorro had yet another environmental classroom. Eventually, a string of 'pocket parks' were created along the river, Escondida Lake was rehabilitated, stands of native trees with a non-native understory were thinned to protect the bosque from wildfire, a saltcedar management program was launched with the mechanical treatment of 400 acres, and members of the task force were working to restore the natural function of the area's numerous arroyos.

Later, the group began to discuss the need for a way to prioritize future projects, and with input from local and regional interests, a restoration plan to address issues such as fire danger, water savings potential, habitat diversity, and endangered species concerns was developed for the San Acacia-to-San Marcial reach of the Rio Grande *(see page 72).*

Figure 7. *Escondida Lake in Socorro County after restoration.* (Photo courtesy U.S. Fish & Wildlife Service)

The Bureau of Reclamation held a series of public scoping meetings as it prepared for rehabilitation of the Low Flow Conveyance Channel at the bottom end of the Middle Rio Grande. In Socorro, landowners, county commissioners, water planners, wildlife biologists from Bosque del Apache National Wildlife Refuge, and representatives from the Socorro Soil & Water Conservation District, the Bureau of Land Management, the MRGCD, the Corps of Engineers, and Elephant Butte Irrigation District turned out to discuss possible solutions to escalating problems with the man-made channel. Concern for wildlife habitat and riparian health signaled a significant change in water operations. Federal agency personnel in particular were beginning to acknowledge that processes such as channel meandering and periodic floods were critical to the vitality of the system.

> *"There was really a transition going on. Those of us who had served on Reclamation's River Assessment Team a few years earlier had started to change our approach to 'restoration.' We were moving away from lining and channelization, and toward softer engineering. We realized we needed to try something different." (Gina DelloRusso, Refuge Ecologist, Bosque del Apache National Wildlife Refuge, personal communication, 2002.)*

The Low Flow Conveyance Channel

Constructed by the Bureau of Reclamation to transport water to Elephant Butte Reservoir with a minimum of loss to evaporation and riparian vegetation, the seventy-mile-long Low Flow Conveyance Channel parallels the river between San Acacia Diversion Dam and the Narrows above Elephant Butte. When work began on the channel in 1951, deposited sediment and dense vegetation so choked the river that it had entirely disappeared in a number of places south of Bosque del Apache, and New Mexico had accrued a debit of 325,000 acre-feet in annual water deliveries mandated by the Rio Grande Compact.

Once completed, the low flow channel's nominal capacity of 2,000 cfs allowed the entire flow of the river to be diverted at San Acacia. On average during the 1960s and early '70s, there were only about thirty days a year—mostly during spring and summer floods—when flows exceeded the conveyance channel's capacity and water was released to the river bed below San Acacia.

Estimates of the amount of water saved through use of the low flow channel are as high as 60,000 acre-feet per year, and in conjunction with a number of other water salvage and efficiency improvements, the Bureau of Reclamation's Middle Rio Grande Project has enabled New Mexico to remain in compliance with the Rio Grande Compact since 1969.

A second function of the low flow channel is to provide an outlet for the valley drainage system. Drainage is critical for maintaining agricultural productivity, preventing the waterlogging of irrigated lands and the accumulation of salts in the root zone. Below San Acacia, the riverbed is elevated above the floodplain and the MRGCD's drains cannot flow to the river by gravity. The low flow channel intercepts subsurface water moving inland from the river, and collects flows from the system of drains, transporting both sources of salvage water downstream to a suitable outfall. Drainage flows in the low flow channel are fairly constant and result in about 200,000 acre-feet annually, or twenty percent of the average inflow to Elephant Butte Reservoir. Diversion structures along the conveyance channel allow accumulated drainage water to be diverted for irrigation by the MRGCD, and for wildlife management at Bosque del Apache. In recent dry years, the Bureau of Reclamation has also pumped water from the channel to the river to maintain habitat for the endangered silvery minnow.

In the mid-1980s, high water levels at Elephant Butte Reservoir inundated the lower fifteen miles of the constructed channel, and in March of 1985, diversions were suspended to it. Once the reservoir receded, the low flow channel was no longer connected directly to the reservoir; instead, it passed through the marshes and wetlands of a vast delta. An especially rich and diverse wildlife community developed in these habitats, including the largest concentration of endangered southwestern willow flycatchers in the Rio Grande Valley.

A number of issues are being debated regarding the future of the low flow channel. There is interest in resuming its operation to take advantage of the potential for water conservation and salvage, especially in light of lowering reservoir levels, projected impacts of water development plans upstream, and the threat of prolonged drought, each of which could affect New Mexico's ability to meet its Compact obligations. But there are also concerns about the

environmental impacts of diverting water from the river. The importance of the San Acacia-to-Elephant Butte reach as habitat for the endangered silvery minnow would be a constraint, and a return to full diversion operations seems unlikely. Diversion of some flows while maintaining a minimum in the river might be considered, however, and the low flow channel is being studied in the context of other federal operations in the Upper Rio Grande Basin.

In a 1999 Draft Environmental Impact Statement, the Bureau of Reclamation also proposed realigning the low flow channel through the upper end of the Elephant Butte delta, below San Marcial. It would involve moving the conveyance channel to the western edge of the floodplain, then breaching the existing levee to allow the river to move into lower floodplain areas. This would alleviate problems associated with sedimentation along the existing river channel, including channel capacity constriction at the San Marcial railroad bridge, which constrains releases from Cochiti Dam. The project would also reduce the threat of an uncontrolled levee breach that would adversely impact both channel conveyance efficiency and existing wildlife habitats. Improved riparian habitat conditions are expected to result from reconnecting the river and the floodplain. Also proposed is an adaptive management plan that would establish specific restoration targets, and a monitoring plan to evaluate conditions and track progress. (Chris Gorbach, Low Flow Conveyance Channel Modifications Study Manager, Bureau of Reclamation, 2002.)

Figure 8 a & b. *San Acacia Diversion Dam and Low Flow Conveyance Channel (inset), Socorro, New Mexico.* (Photo courtesy of U.S. Fish & Wildlife Service)

In February, a draft report on the "potential economic consequences of designating critical habitat for the Rio Grande silvery minnow" (U.S. Fish & Wildlife Service, 1996) was released for public comment. The report, prepared by ECONorthwest, of Eugene, Oregon, was part of a congressionally mandated review of the impacts of federal water policy on the West. A variety of New Mexico state agencies, local governments, and agricultural interests expressed fury over ECONorthwest's dismissive characterization of water use in the Upper Rio Grande basin as "suboptimal," and at its annual meeting in March, the Rio Grande Compact Commission passed a resolution requesting that the report be rejected.

As yet, however, there *was* no official habitat designation for the silvery minnow. The U.S. Fish & Wildlife Service had ceased efforts in that direction in 1995, when Congress rescinded funding for all pending habitat designations and final listings. On April 9, 1997, Forest Guardians and Defenders of Wildlife filed suit in federal district court over the government's failure to designate critical habitat for the minnow. That same day, the U.S. Fish & Wildlife Service's Regional Solicitor notified the Middle Rio Grande Conservancy District that the federal agency had "changed its mind" and now intended to file a Notice of Violation for the MRGCD's alleged 'take' of minnows in 1996 (MRGCD board minutes, April 14, 1997). Together, the two actions sparked a domino effect of counter suits, interventions, stays, and appeals that would reverberate for the next five years, making budding efforts to collaborate on ecosystem restoration an even greater challenge.

The City of Albuquerque had published an evaluation of thirty-two alternatives for the direct use of its San Juan-Chama water for municipal consumption. Public comment was solicited at a series of informational meetings, but the diversion plan initially failed to raise much concern within the environmental community. Though methods for removing 48,200 acre-feet of water a year from the river were up for debate, few questioned the effect such an extraction might have on the overall well-being of the stream system.

After ten years without one, the City of Albuquerque and the MRGCD were directed by state legislators to negotiate a Joint Powers Agreement for managing Rio Grande Valley State Park. Albuquerque Open Space Division had been pole-planting cottonwoods in the park since the mid-1980s, but now there were plans for removing saltcedar and other exotics, as well as interagency efforts to mechanically reconfigure sections of riverbank to foster overbank flooding for cottonwood generation. In response to negative comments regarding the MRGCD's prior management of riparian lands, its board members took out a half-page ad in the *Albuquerque Journal*. Reactive or not, the message reflected a concerted change in the agency's philosophy:

> "The conservancy's mission...includes provision and maintenance of open space and recreational areas and a statutory charge to work generally for the public welfare...There never has been in the past, nor would it be possible to create in the future, any agency such as the Conservancy whose sole mission relates to the land and water of the middle valley, and which stands ready and willing to protect the beautiful bosque in the best interest of the people and communities [of the Middle Rio Grande]."

The MRGCD was under pressure from another quarter, too. The Office of the State Engineer had requested a Proof of Beneficial Use, pending since 1931, on the MRGCD's permits to irrigate 123,257 acres in the middle basin. Over the years, successive extensions had been granted for filing the paperwork, but as the MRGCD prepared to implement its plan for banking and leasing "unused" irrigation rights, the State Engineer handed down a December 1997 deadline for submitting the Proof of Beneficial Use.

Exactly where the Rio Grande's water was being expended was a pivotal question. Researchers understood that evapotranspiration (ET) played a huge part in the water balance of desert stream systems, but they did not know the actual rate at which mixed stands of saltcedar, cottonwood, and Russian olive take up water and release it into the air. Neither could they say for sure what effect flooding or riparian restoration efforts might have on ET rates in the bosque. To begin exploring such questions, the University of New Mexico's Department of Biology and U.S. Fish & Wildlife's Ecological Field Services Office in Albuquerque cosponsored an informational symposium on the Role of Evapotranspiration in Southwestern Riparian Ecosystems, held at the Sevilleta Field Station in April. As ET experts, ecologists, hydrologists, researchers and resource managers learned about different techniques for measuring evapotranspiration, they agreed that comprehensive models of the basin would have to take into consideration surface flows, groundwater/surface water interactions, riverbank storage, riparian restoration, ET rates in uplands and other basin landscapes, recharge from ephemeral channels and other sources, infiltration rates, water quality, and biological research. They also thought it important that simplified evapotranspiration and consumptive-use numbers should be made available to legislators and other political decision-makers.

> *"Wise management of a watershed ultimately hinges on understanding its mass balance. Like a bookkeeping system in any business venture, there must be a reckoning of how much water comes in and how much goes out. The ledger includes (1) the sum of precipitation a catchment receives, (2) the rate of evaporation and transpiration taking place across the same area, (3) the amount of water in storage as groundwater or in reservoirs, and (4) the volume of water that exits the catchment as runoff." ("Factoring In Evapotranspiration," Lisa Robert, New Mexico Water Dialogue, 1997.)*

In June, New Mexico First held a two-day Town Hall on "Managing New Mexico's Land and Water Resources For the Best Use, Now and Through 2020." Among other things, participants suggested that all public entities with a role in water management or land use be examined to better coordinate and simplify their activities. "Collaborative decision-making among federal, state, regional, local, and tribal jurisdictions, elimination of duplication, increased public and local input, and overall accountability, are essential for effective land and water management." The group also thought that water conservation should be encouraged, and expressed a preference for "applying incentives, price breaks, and tax advantages for compliance and superior performance, rather than surcharges, penalties, and fines for noncompliance." Not least, they acknowledged that for many regions, a crisis was already at hand in regard to land and water management, and recommended that "growth management" be addressed in a future Town Hall (New Mexico First, 1997).

To meet the conditions imposed on its 1994 permit to pump groundwater, Intel Corporation had applied to the State Engineer to transfer 2,027 acre-feet of water rights from the abandoned farm community of San Marcial in Socorro County. The area had not been irrigated since a destructive flood in the 1920s, and the transfer of inoperative water rights upstream to Rio Rancho had implications for water users throughout the fully appropriated basin. Hearings on the request commenced in Socorro in August. Thanks to a draft of the Socorro/Sierra Regional Water Plan, the case was the first in which a New Mexico State Engineer had guidance regarding an area's preference for how water should be used or transferred, and although the final decision was not based on issues of public welfare, the Intel application was eventually denied.

That same month, regional water planning was also arousing considerable interest upstream of Socorro. State Engineer Tom Turney, along with the Governors of Santa Ana, Santo Domingo, and Isleta Pueblos, issued a call to stakeholders in the Rio Puerco, Rio Jemez, and Middle Rio Grande drainages to

participate in an "assembly" at the University of New Mexico to discuss the formation of a regional water planning committee under the umbrella of the state's ongoing program. The Middle Rio Grande was the only one of sixteen regions without such a planning process, and a cross-section of concerned individuals from academic and agency circles had raised the money to sponsor an initial gathering. Turnout was good at the August event, but many stakeholders came with misgivings. Tribal representatives expressed reluctance to participate in water planning because Pueblo water rights in the Middle Rio Grande remained unquantified. The MRGCD also viewed the initiative as something of a threat and determined to hold its own series of meetings to elicit input from its ratepayers. Still, support for water planning was widespread and at a second meeting in November, a grassroots steering committee was elected to oversee work on a regional plan. Almost immediately, the Middle Rio Grande Water Assembly became a vocal player in the region's water affairs.

Regional Water Planning in New Mexico

In 1987, after a decade-long battle to bar El Paso from pumping New Mexico groundwater, it had become clear the state's old embargo statute could no longer be counted on to protect unappropriated water resources. Instead, the legislature authorized a Regional Water Planning Program to ascertain the future supply needed in each of eight (and later sixteen) hydrologically/politically determined areas. The logic was that future water needs could best be determined at a regional level, and by applying for the right to that water under specifically tailored forty-year plans, New Mexico might protect its water from exportation to fast-growing areas adjacent to the state's borders. Regional planning was envisioned as a bottom-up process, to be funded through the New Mexico Interstate Stream Commission, and carried out by the collaborative efforts of stakeholders and local governments.

The initiative met with varying degrees of success. In areas where water right adjudications were underway, constituencies were so polarized that lack of trust often undermined the planning process. In some regions, water plans were developed with a minimum of public input and the end product had little chance at widespread support. In other places, an organic mix of citizens, scientists, elected officials, public agencies, and non-governmental organizations made for unwieldy steering committees and slow progress.

In spite of these difficulties, regional water planning offered the promise that local values might drive future water resource decisions, and that traditional and environmental water uses might be protected along with those aimed primarily at creating economic growth. The process also provided an in-depth education to a diverse array of citizens so that today, hydrologic and resource management issues are better understood by the lay public than would ever have been the case without regional planning.

Since the program's inception, the Interstate Stream Commission has dispersed some $5.5 million in Regional Water Planning funds, and all but two plans have been completed. On the downside, the documents have no power beyond the willingness of local governments to adopt the alternatives proposed, and as yet, no clear blueprint exists for how to merge these separate visions under a state water plan. Regional water planners have proved to be steadfast players, however, and the public forums they have created appear to be permanent additions to New Mexico's unique brand of resource management. Thanks in part to regional thinking, greater emphasis is beginning to be placed on watershed health, and on cooperation between agencies that manage land and water.

Tribal governments in the central Rio Grande were weighing the risks posed to their senior water rights by endangered species initiatives, regional water planning, pressure on the MRGCD to prove beneficial use on all its agricultural acreage, and transfers of water for industry and municipal growth. One response was the resumption of the Six Middle Rio Grande Pueblos' Irrigation Committee. First formed in 1980, the committee included representatives of the Pueblos of Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia and Isleta, all of which receive their irrigation water through the works of the MRGCD. With a Bureau of Indian Affairs' Southern Pueblos Agency engineer as go-between, the committee was responsible for requesting the storage and release of "prior and paramount water" at El Vado Reservoir, and for bringing to the attention of the MRGCD and the Bureau of Reclamation any problems or shortages experienced during the irrigation season. Communication between the Irrigation Committee and the MRGCD had suffered over the years, particularly during the long process to renew a lapsed maintenance contract. Now, given proliferating water agendas in the basin, the forum had been resurrected, and attendance was reported as "strong." In addition, the Governors of the Ten Southern Pueblos (the above-mentioned six, plus Jemez, Zia, Laguna and Acoma,) had formed a coalition and appointed a committee to keep tabs on water issues of all kinds. (MRGCD Board of Directors' meeting minutes, May 29, 1997.)

At the seventy-year-old MRGCD, there was yet another sign of the times: in September, the agency hired its first-ever biologist and planner to work on endangered species and bosque-related issues, and to try to bridge the gap between the provincial agency and an increasingly critical environmental community.

There were, it seemed, constant grounds for environmental advocates' frustration. In settlement of a Forest Guardians/Southwest Environmental Center lawsuit alleging that New Mexico had failed to develop satisfactory Total Maximum Daily Loads (TMDLs) for various pollutants in its affected streams, the U.S. Environmental Protection Agency began requiring watershed recovery plans establishing TMDLs for each body of water violating New Mexico water quality standards. Soon thereafter, the New Mexico Environment Department proposed removing more than seventy reaches from its 303(d) list of assessed rivers and streams requiring Total Maximum Daily Loads because there was "no data to indicate that water quality in those reaches was impaired." ("*The ABC's of TMDLs*," Susan Gorman, New Mexico Water Dialogue, 1998.)

One final flourish marked 1997: despite earlier opposition, Governor Gary Johnson issued an Executive Order directing the Secretary of the Department of Energy, Minerals, and Natural Resources to initiate "an independently-facilitated consortium for bosque management entities and other stakeholders" for the "greater good" of the Rio Grande bosque.

1998

With funds from the Bureau of Reclamation, U.S. Fish & Wildlife Service, the Corps of Engineers, USGS, and the Office of the State Engineer, the MRGCD began installing a real-time, automated water measurement system to keep tabs on its diversions and to gage return flows from all of its irrigation and drainage facilities. Data downloaded from satellite by the Corps of Engineers was to be transmitted to the MRGCD every four hours by phone and converted by special computer software into hydrographs for any point on the river. In conjunction with a network of weather data collection stations capable of measuring rainfall, soil moisture, wind speed, and humidity, the system could be used to predict irrigated crop requirements and to maximize available water. The more immediate product, of course, would be improved numbers about how much water the MRGCD was actually using.

Plans for a series of films on water issues in the Middle Rio Grande were announced by the City of Albuquerque's water conservation communication consultant, Cooney-Watson and Associates. The firm had already produced a number of works for the City, including *The Well Runs Dry*, *Quenching Our Thirst* and *San Juan-Chama: A Tale of Two Legacies*. The new series, *Hell or High Water,* would eventually air on two local network affiliates, informing more of the public about the region's water situation than ever before.

In an Opinion issued on March 27, State Attorney General Tom Udall determined that New Mexico law permits the State Engineer to give legal protection to instream flows for recreational and ecological purposes, and that no prohibition exists against the acquisition of water rights for instream uses as long as the transfer receives the approval of the State Engineer (New Mexico Attorney General, 1998). The Opinion represents the first recognition of a stream's 'right to water' by an entity of state government, but that view has yet to be tested in court.

Also that spring, the Middle Rio Grande Water Assembly was mulling the first draft of a regional water budget developed from existing data by a cadre of hydrologists and other specialists. Their conclusions sparked an uproar: in spite of return flows from some 70,000 acre-feet of groundwater being pumped from the aquifer, and in spite of the feast of San Juan-Chama water imported into the Rio Grande system since 1972, and in spite of having just been blessed by the two wettest decades in the last 2,200 years, the region's water account appeared to be vastly overdrawn.

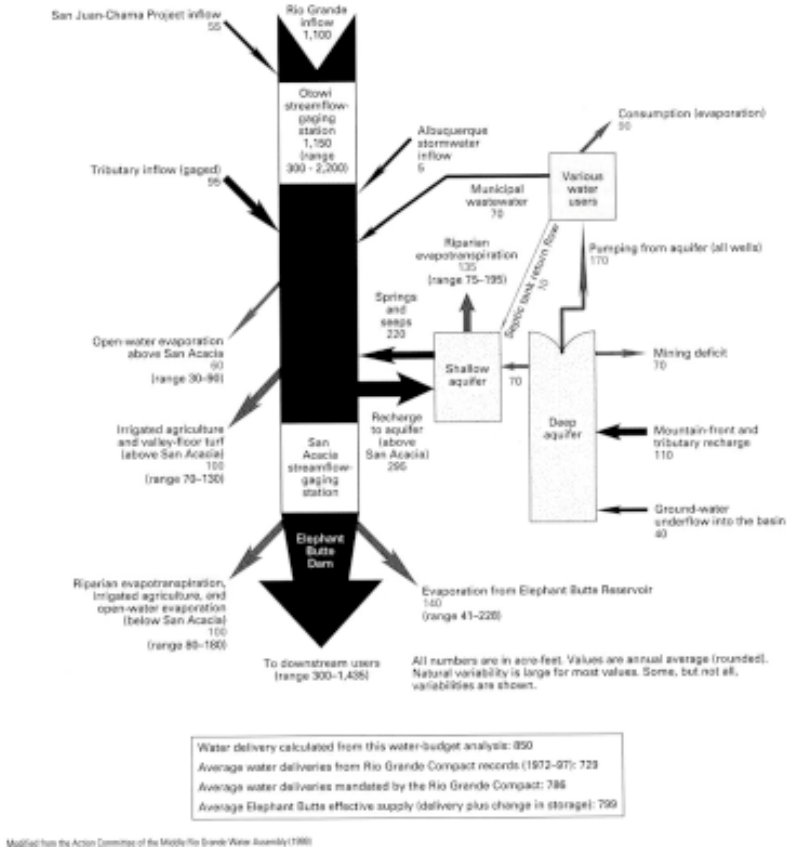


Figure 9. *Middle Rio Grande Water Budget showing inflows and outflows for the Middle Rio Grande water planning region.* (Diagram courtsey Middle Rio Grande Water Assembly)

Governor Gary Johnson officially declared April 25, 1998 as Bosque Appreciation Day, and encouraged citizens to become involved in any of the ongoing preservation initiatives. There were a number of projects to choose from. One of many collaborative efforts taking its cue from the *Bosque Biological Management Plan* was the Albuquerque Overbank Project. Participants included the University of New Mexico, City of Albuquerque Open Space, the MRGCD, New Mexico Natural Heritage Program, New Mexico Environment Department, Bureau of Reclamation, the Corps of Engineers, and U.S. Fish & Wildlife Service. At a site north of the Rio Bravo Bridge in Albuquerque's South Valley, heavy equipment operators began clearing and root plowing dense stands of Russian olive on an alternative river bar that received little overbank flooding. The elevation of the bar was lowered approximately two feet, and terraces and a side channel were created. The site included a grid of piezometers to monitor river/groundwater interaction, and a weather station. At the end of the first year, some 8,000 cottonwood, coyote willow, saltcedar, and Russian olive seedlings had been sown by receding floodwater, and bank sloughing had widened the active flood plain by some fifteen percent.

Albuquerque Overbank Project

In the fall of 1997, a collaborative team from the Bureau of Reclamation, City of Albuquerque Open Space, the Middle Rio Grande Conservancy District, U.S. Fish and Wildlife Service, the New Mexico Natural Heritage Program, and the University of New Mexico's Department of Biology agreed there was a real need to understand how to reestablish healthy native vegetation in the Middle Rio Grande bosque. They began looking for a likely site in the Albuquerque reach where they might evaluate the efficacy of using artificial site preparation and natural vegetation processes.

The group planned to address an area roughly five to fifteen acres in size, and to create opportunities for restoring the site to a better condition by removing nonnative vegetation, lowering banks to reconnect the river to its floodplain, allowing for natural reestablishment of native vegetation, encouraging topographic variability and transition zones for vegetation establishment, and by carving artificial channels to aid diversity and benefit both fisheries and wildlife.The project required a location not in heavy use by the public, and not subject to vandals; it also needed to be in poor overall condition, dominated by nonnative vegetation, and disconnected from the river but within reasonable distance to the active channel so that the area could be 'reconnected' without moving tremendous amounts of soil. State water quality standards prohibit sediment from being deposited directly into flowing water, so whatever fill was produced during bank lowering would have to be accommodated on site. The proposed work could not be detrimental to any infrastructure (e.g., the levee system), and nearby features such as arroyos that might detrimentally impact the project by filling in the designed channel would also have to be taken into consideration.

A site upstream of the Rio Bravo Bridge in south Albuquerque met the above criteria. Best of all, there was a low river bar nearby where material removed from the bank could be deposited. Allowing the river to naturally transport this sediment downstream offered not only a reduction in project costs, but a nutrient benefit to the overall riverine system: the Rio Grande has historically been a 'sediment rich' system, but intervention by man, including the construction of dams which hold back sediment and levees which prevent overbank flooding from spreading it across the floodplain, have severely impacted the river's overall health.

In March 1998, work began on the Overbank Project using Bureau of Reclamation equipment and operators. The four-acre site, dominated by monotypic Russian olive, was cleared and

root plowed, and about half of the acreage was lowered to allow for flooding during spring runoff events. The resulting soil was deposited on the lower bar and blended with the existing topography. Shallow channels, various elevations or terraces, and undulations were created to mimic conditions found in nature and to encourage regeneration of native vegetation. Approximately 8,000 cubic yards of material was also removed from the upper bar, hauled away, and later shredded by City of Albuquerque Open Space.

Equidistant east-west lines of shallow groundwater wells were set up to examine the relationship of river flow to groundwater dynamics on the cleared bar and in the untreated bosque directly to the west and north. Plant succession was measured using a grid system and transects. Soil salinities were also measured and soil textural types identified.

The Overbank site flooded in 1998, 1999, and 2001. Flooding varied in extent and duration, and occurred between discharges of 2,500-5,000 cfs. Groundwater levels correlated well with river discharge and had the greatest amplitude in wells nearest the bank. Due to erosional changes in the bank profile, the adjacent river is now more variable in channel depth, width, and discharge velocity. The bank has eroded by an average of 80 feet, increasing the river's width by fifteen percent, and new bar formation via material relocation has also occurred.

Over 8,000 cottonwood seedlings and smaller numbers of willows, Russian olives and saltcedars were established during the first flood season. Most of the cottonwoods died before the second season. The several thousand survivors range from one to three meters in height, and occur in sandy-loam soils that characterize much of the site. The first year, relatively saline soils supported large stands of sunflower, but white sweetclover began to replace them the following year. Russian olives are concentrated near much of the eroding bank line.

The Albuquerque Overbank Project has remained unmanaged since 1998 and could be a useful model for Middle Rio Grande riparian restoration in that it has an abundance of young native trees, and a great diversity of habitats all initiated by overbank flooding. (Cliff Crawford, University of New Mexico Department of Biology, and Nancy Umbreit, Bureau of Reclamation, 2003.)

Figure 10. *Cleared sandbar at the Albuquerque Overbank Project*. (Photo courtesy of Nancy Umbreit)

Also that year, a novel outreach program was getting underway in New Mexico. The U.S. Bureau of Reclamation had purchased two 5' by 10' flatbed trailers designed by a Colorado company to serve as textbooks on the nature of moving water. Essentially a big sandbox filled with granules of recycled plastic that could be sculpted to represent uplands and floodplains, the trailers were plumbed to allow recycled water to flow from one end of the bed to the other. The mobile classrooms soon began making the rounds of fairs, schools, and workshops, giving students of all ages the chance to play with watershed basics and stream morphology. The Rolling River's cooperative partners included the Bureau of Reclamation, the New Mexico Association of Conservation Districts, the New Mexico Department of Agriculture, the Office of the State Engineer, and the Natural Resource Conservation Service, which administered the program throughout the state.

In June, a four-day symposium and workshop entitled "Rio Grande Ecosystems: Linking Land, Water and People," jointly sponsored by the U.S. Forest Service's Rocky Mountain Research Station and the Bosque Initiative, highlighted ecosystem-related work underway in multiple fields. Categories included "People, Culture, and Communication," "River and Riparian Issues," "Watershed Issues," "Restoration and Monitoring," and "Biodiversity and Endangered Species." In addition, there were field trips to examine Corps of Engineers' mitigation and revegetation work in the Rio Grande bosque, riparian management techniques at Bosque del Apache National Wildlife Refuge, and Bureau of Land Management reforestation and riparian restoration projects in the Rio Puerco watershed (Finch et al., 1999).

Not long thereafter, as directed by the Governor the previous fall, a meeting was held at the Indian Pueblo Cultural Center to discuss the formation of a Bosque Consortium. The new group would serve as "a central coordinating structure to enhance ecological functions and support each entity with jurisdictional authority along the bosque to make decisions in consultation and coordination with other entities and stakeholders for the greater good of the bosque." It was also intended as a forum for educating the Middle Rio Grande community and its decision-makers on issues regarding the bosque, and as an instrument for meaningful public involvement. Not least, it meant to pave the way for restoration partnerships and collaborative projects. Funds for the effort were to come from the state via the Middle Rio Grande Council of Governments, with decisions to be made by a steering committee. In order to move the group toward its vision of "a perennial Rio Grande whose flows mimic the natural fluctuations to the maximum extent possible, and a river channel that is permitted maximum freedom within the floodway," subgroups were formed to address such issues as biodiversity, agriculture, fire management, river flow, recreational use, urbanization, flood management, and awareness of the bosque as a community asset. Matters of funding and authority proved to be stumbling blocks for the Consortium, however, and after a number of annual meetings and a workshop on fire in the bosque, the group's more salient initiatives were assimilated by other forums. Still, interaction between Consortium participants, and the knowledge gleaned from their open discussion, persists today in other guises.

The Bosque Consortium River Flow Work Group

One Bosque Consortium subcommittee that would have enduring influence was the River Flow Work Group, whose members first set out to develop a management plan for mimicking the Rio Grande's natural hydrograph, and to address conservation incentives for irrigation in both agricultural and urban settings. There was more to achieving a healthy flow regime, they agreed, than simply increasing the volume of water in the stream: sediment movement, channel morphology, diversity and abundance of native vegetative communities, and the prevention of human encroachment onto the floodplain were also vital to the river's health.

The River Flow group met monthly after April of 1999 to develop a vision of a healthy river; to inventory the restoration projects already underway in the middle valley; to identify the agencies, municipalities, tribes and other entities with authority or responsibility along the river corridor; and to explore opportunities for positive action. In 2000, the group produced a list of 'Action Possibilities' deemed to have "high value and a high probability of success." These included addressing choke points like the San Marcial railroad bridge, and preventing further development in the 100-year flood plain so that the system could accept higher flows; amending the spring runoff hydrograph to provide periodic overbank flooding; removing jetty jacks wherever feasible to expand the active river channel; managing sediment inflow to those portions of the river that were degrading; monitoring key aspects of ecosystem and physical system change; determining and prioritizing research needs; restoring the mosaic of native communities in the bosque and quantifying the water savings—if any—of removing non-native vegetation; studying the potential for greater irrigation efficiency in the MRGCD; conducting community-based outreach to educate the public on the value of the river ecosystem; acquiring water from willing sellers; and creating some sort of dedicated storage for water for the river.

The group also noted a number of high-value enterprises they believed at the time would be greater challenges to achieve: collaboration with the tribes to implement river restoration; increased storage of native Rio Grande water upstream; conjunctive use of ground and surface water; integrated management throughout the Middle Rio Grande and its watersheds to protect biological quality and ecosystem diversity; involving the Rio Grande Compact Commission in active water management decisions; expanding the "controlled flood-prone area;" initiating a general tithe to the river; getting state and municipal governments to enact laws to protect the river; establishing some form of permanent flow from Cochiti to Elephant Butte; and adjudication of the basin's water rights.

These concepts have been carried forth and integrated into other initiatives by River Flow Work Group members, many of whom participate in ongoing ecosystem research and river restoration programs. The group also provided the impetus for the review and update of the Bosque Biological Management Plan.

Other opportunities to approach problems collectively were also gathering momentum. Signatories to the 1996 water management strategy known as the White Paper (Whitney et al., 1996) had managed to keep water in the river for the silvery minnow through two previous irrigation seasons, thanks in part to a lease agreement between the Bureau of Reclamation and the City of Albuquerque for up to 30,000 acre-feet a year of the city's San-Juan Chama water. But with the agreement due to expire in 1999, and plans in the works by both Albuquerque and Santa Fe to begin diverting San Juan-Chama water for direct use, environmental interests decided to join forces to advocate for more ecologically-oriented river management. Spearheaded by an organization called the Land and Water Fund of the Rockies, (currently known as Western Resource Advocates), a collection of groups including American Rivers, the Conservation Trust, Conservation Voters Alliance, Defenders of Wildlife, Forest Guardians, the National Audubon Society (New Mexico), National Parks Conservation Association, Rio Grande Restoration, the Sierra Club, and the Southwest Environmental Center convened what would become the Alliance for Rio Grande Heritage and began drafting a document aimed at implementation of the White Paper. The 'Green Paper' (Alliance for the Rio Grande Heritage, 1998) offered a roadmap that went several steps further than the water managers' set of action alternatives. In

particular, it advocated: getting the Middle Rio Grande Conservancy District to commit to making water deliveries more efficient, and to consider initiating an irrigation forbearance program; replacing San Acacia Diversion Dam with something more environmentally friendly; urging the Bureau of Reclamation to purchase or lease uncontracted San Juan-Chama water and store it in Heron Reservoir for meeting endangered species needs; appealing to the federal government to purchase water from willing sellers after determining environmental streamflow requirements; convincing the New Mexico Interstate Stream Commission to time the state's Rio Grande Compact deliveries to coincide with ecosystem needs; and encouraging entities like the City of Albuquerque and the MRGCD to consider making a tithe of water to the river. The Alliance formally invited federal and state agencies and interested stakeholders to participate in a dialogue regarding the concepts contained in the Green Paper.

Fittingly, the first meeting of what became known as the Green-White Dialogue occurred at Sol y Sombre in Santa Fe in the summer of 1998, beneath a display of black and white photos of the ruins of Chaco Canyon, abandoned sometime in the 13th Century in response to what archaeologists term "environmental change."

1999

Unfortunately, collaboration had not yet trumped litigation. With prospects for a below-average spring runoff, and a court duel forthcoming over the designation of critical habitat for the silvery minnow, an assortment of environmental groups sent a January letter to the Bureau of Reclamation and the U. S. Army Corps of Engineers. It was another 60-day Notice of Intent to Sue, designed to goad water managers into major revision of Rio Grande water operations.

River Day at the Roundhouse

To awaken concern among state legislators for the plight of the Rio Grande and other New Mexico rivers, the first River Day at the state legislature was organized by Rio Grande Restoration in February of 1999. "Celebrate New Mexico's Rivers" was created to recognize the "cultural, spiritual, economic and environmental significance of our rivers, with special attention to the Rio Grande."

Federal, tribal, state and local agencies plus a broad range of non-governmental organizations participated in the event, providing informational displays, speakers, poetry, music and dance presentations. Exhibitors included A Gathering of Waters; Adobe Whitewater Club; Amigos Bravos; the U.S. Army Corps of Engineers; Bosque del Apache National Wildlife Refuge; the Bosque Ecosystem Monitoring Program; the U.S. Bureau of Reclamation; the City of Albuquerque Open Space Division; Defenders of Wildlife; Forest Guardians; the New Mexico Interstate Stream Commission; National Audubon Society; National Parks Conservation Association; New Mexico Association of Conservation Districts; New Mexico Environment Department Surface Water Quality Bureau; New Mexico Natural Heritage Program; New Mexico Riparian Council; New Mexico Office of the State Engineer Water Conservation Office; New Mexico Trout; Piñon Elementary School (Los Alamos); Project del Rio; Project

Green (Santa Fe Prep with New Mexico Game & Fish Department); Pueblo of Santa Ana Natural Resources Program; Rio Grande Gorge Visitor Center (Bureau of Land Management); Rio Grande Restoration; Rio Grande/Rio Bravo Basin Coalition; Santa Clara Pueblo Office of Environmental Affairs; Santa Fe River Coordinator; Santa Fe Watershed Association; Sierra Club Rio Grande Chapter; Southwest Environmental Center; Tierra y Montes Soil and Water Conservation District; the U. S. Fish and Wildlife Service Ecological Services; Watershed Watch; Wild Friends (University of New Mexico Center for Wildlife Law); and the Wildlife Legislative Council.

In conjunction with the first "Celebrate New Mexico Rivers" program, New Mexico Speaker of the House Raymond Sanchez sponsored a House Joint Memorial (HJM-47) acknowledging "the precious gifts bestowed upon us by our great rivers," recognizing them as "the source of inspiration, pleasure and spiritual renewal for our citizens of diverse cultures."

River Day has since become a biennial event, known as Rio Grande Day, and occurs during alternate year "full" legislative sessions at the Roundhouse.

As luck would have it, a late spring storm brought substantial moisture to the thirsty system, and even as opponents sued, petitioned, and intervened in a maze of legal proceedings regarding the silvery minnow, cautious discussions continued among participants in the Green-White Dialogue. Together, water managers and environmentalists had already produced a working paper called, "Water for the River: Points of Action," which specified desired actions to be undertaken by agencies and stakeholders. A subcommittee was then formed to consider implementation. One action item resulted in a feasibility study on the removal of San Acacia Diversion Dam. Other actions for discussion included MRGCD irrigation efficiency, relocation of the San Marcial railroad bridge, modifications to levees and jetty jack removal, the need for state and municipal drought contingency plans, a moratorium on water right transfers, and improved management of the upper watershed.

Now New Mexico Interstate Stream Commission engineer Norm Gaume appealed to the group to explore "alternative processes for good faith collaborative problem-solving regarding water needs for the silvery minnow." The ad hoc gathering responded with a set of "mutually acceptable conceptual goals" that included recovery of the minnow; setting water aside for Native American uses; supplying adequate water for valid rights and uses; managing the water supply to meet New Mexico's Rio Grande Compact obligations; avoiding any Fifth Amendment takings; maximizing incidental benefits to the river and riparian systems while managing flood flows for public safety, sediment management, and river morphology; managing San Juan-Chama water in compliance with state and federal law; recognizing water supply limits; conserving water; and working together to establish priorities, secure funding, and implement solutions. A list of "mutually acceptable recovery strategies" that could be implemented in the short term was also generated. Priority was given to involving the Pueblos in restoration efforts, to creating new habitat in upstream areas, to the possibility of a minnow hatchery in the Albuquerque reach, and to acquiring water and storage space for supplemental flows.

But what was really needed was a reduction in the number of river-oriented forums, all of which were dealing with essentially the same questions, and soaking up the time of mostly the same set of participants. It was acknowledged that agreeing on a single set of goals would "be a powerful factor in securing congressional support," even as it would help to minimize duplicated effort.

Green-White Dialogue

The ad-hoc entity known as the Green-White Dialogue or the Green Paper-White Paper Group met on a regular but informal basis from the summer of 1998 to the autumn of 1999. It involved representatives from New Mexico's congressional delegation; from each of the federal water management agencies; from the New Mexico Interstate Stream Commission and the Office of the State Engineer; from the Cities of Albuquerque and Santa Fe; from the MRGCD; and from most of the environmental groups with an interest in the Rio Grande. Several Pueblo governments also maintained an unofficial presence. The Albuquerque District Corps of Engineers provided space to hold the talks, and there was a facilitator to referee the exchange. Against an increasingly litigious backdrop, here was an opportunity to raise the learning curve on all fronts, a place where rumor and allegation might begin to be defanged, and where creative ideas could be floated like helium balloons.

The Green Paper-White Paper Group focused much of its attention on river conditions from San Acacia Dam to Elephant Butte Reservoir, with particular interest in the dam itself, the San Marcial railroad bridge, and the Bureau of Reclamation's review of Low Flow Conveyance Channel operations. At that time, Reclamation was considering how the artificial channel might be reconfigured to provide more efficient conveyance to Elephant Butte Reservoir, adequate valley drainage, sediment management, and high flow channel capacity, while controlling operation and maintenance costs, safeguarding two endangered species, and fostering ecosystem health and productivity. It was a very tall order. One option was to realign both the Rio Grande and the Low Flow Channel below San Marcial to expand the river's active floodplain. Few other sites exist in the urbanized river corridor where such an expansion could be undertaken, and the concept was an exciting one for river restoration advocates. Such a scheme required an evaluation of the possible impacts to existing riparian areas, wetlands, and willow flycatcher habitat, and water managers would also have to determine the effects of both high and low water levels at Elephant Butte, not far downstream. It was expected that channel relocation would require a five-to-ten-year transition period, and would cost $20 million.

Another energetic initiative to emerge from the Green-White discussions was a team interested in floodplain management. Development on the floodplain, particularly in Socorro County, had been a problem for the Corps for some years, potentially limiting the size of flood releases that could be passed through the system, along with the environmental benefits of such a pulse. A discourse had been underway between the Corps of Engineers and Socorro County over a house constructed in 1989 on the very brink of the river channel, well within the two-year floodplain. Socorro had no zoning ordinances to discourage such development, and Corps personnel found themselves hamstrung by the sudden appearance of a dwelling they had to protect from flooding, even as it stood in the way of relatively modest releases. Though the Corps briefed the Socorro County Commission on the need for floodplain integrity, the commission had declined to undertake a zoning ordinance on the grounds that it would constitute a 'take' of private property. Members of the floodplain group instead began to explore the idea of conservation easements to keep structures out of the floodplain. They approached several entities about the possibility of holding such easements, including the Socorro Save Our Bosque Task Force, the MRGCD, and the Socorro Soil & Water Conservation District. To create an incentive for local support, landowners that granted a conservation easement to limit development on their lands would also reap the benefits of riparian restoration, exchanging a mosaic of meadows, forests and savannas for a monoculture of saltcedar.

Tinderbox thickets of that particular exotic had fueled major wildfires in the region, and Socorro's residents, for the most part, were more concerned about fire than flood. A strategy that could at once alleviate both hazards proved to be a stroke of genius; today, several pilot projects are underway, and there is no shortage of interest in the program.

Two other issues often debated at Green-White meetings were 'forbearance' and supplemental water acquisition. There was widespread but not unanimous belief that the Middle Rio Grande Conservancy District represented a potential supply of wet water for both the silvery minnow and riparian restoration efforts. Perhaps individual irrigators could be persuaded to forego using all or part of their water in a short water year, and the salvage could be applied to maintaining flows in the river. But in the absence of a Proof of Beneficial Use, forbearance raised issues of water right ownership and priority within the MRGCD. The agency was sometimes hard pressed to provide sufficient water to its constituents even in an average year, and there were concerns that if irrigators began assigning their annual allotments to the river, vested rights might be impaired. San Juan-Chama allocations were already being tapped to address ecosystem needs, as long as a shell game was played to exchange the imported water for native water. The Bureau of Reclamation had acquired 58,000 acre-feet of supplemental water for the minnow over the summer of 1999, but there were difficulties associated with that strategy, too: there was nowhere to store supplemental water that might be left over at the end of the season.

Litigation charging the Bureau of Reclamation and the U.S. Army Corps of Engineers with the decline of the Rio Grande ecosystem would eventually dissolve the Green-White forum, but not before seeds of communication had been planted between environmentalists and the water management status quo.

In early July, just as the acrimony of species litigation was beginning to unravel the Green-White discussion, the U.S. Fish & Wildlife Service issued its Draft Rio Grande Silvery Minnow Recovery Plan. The plan identified four necessary actions: restoration and protection of habitat within the middle valley to stabilize and enhance the minnow population; reestablishment of the species into suitable habitat within its historic range; design and implementation of a public awareness and education program; and implementation and maintenance of an adaptive management program, along with appropriate research, to attain recovery of the species (U.S. Fish & Wildlife Service, 1999).

That same month, Senator Pete Domenici hosted a public meeting to initiate a new process he hoped would result in a Habitat Conservation Plan for the minnow. The resulting "Endangered Species Act Workgroup" was composed primarily of the same parties that had participated in the Green-White Dialogue, and they recognized the importance and the difficulties involved in trying to keep the river wet below San Acacia Diversion Dam. Major problems had been identified there, including the MRGCD's diversion dam, which prevented minnows from retreating upstream in times of low flow; the Low Flow Conveyance Channel, which dictated a near-abandonment of the river in order to move water to Elephant Butte; the limits imposed by the San Marcial railway bridge, known as 'the stopper' for the entire system because it is inundated by flows of 4,000 cfs, thus placing a constraint on overbanking throughout the middle valley; and the encroachment of unregulated development onto the Socorro area floodplain. The workgroup's members were also exploring an idea being championed by the state, the agricultural community, and by Senator Pete Domenici: perhaps the silvery minnow could be moved upstream in low water years and maintained in specifically constructed backwaters in the Albuquerque reach, or above Bernalillo on various Pueblo lands. The ESA Workgroup held a year's worth of intensive, facilitated negotiations on a Program Document it was hoped would consolidate all

actions toward recovery of the silvery minnow. Over time, the Workgroup created the Middle Rio Grande Endangered Species Act Collaborative Program (ESA Collaborative Program), which would become the conduit for more than $35 million in funds for habitat, water acquisition, and science projects aimed at improving the status of the silvery minnow and southwestern willow flycatcher while protecting existing and future water uses.

River restoration had been underway at the Pueblo of Santa Ana for some time, funded, in part, by the Bosque Initiative/Bosque Improvement Group. Natural resource personnel, in conjunction with the Corps of Engineers, had been mechanically removing saltcedar, Russian olive, and jetty jacks on 300 acres of bosque in hopes of reestablishing the cottonwood forest and generally restoring the riverfront. Of particular concern was the loss of wildlife habitat and vegetation used for cultural purposes, and the reduced recreational opportunities for tribal members due to heavy undergrowth in the bosque. In 1999, the restoration effort was expanded, and in conjunction with the Bureau of Reclamation, Santa Ana began work to mitigate the deeply incised river channel with grade control structures to halt the erosional process known as down cutting, and to restore the river's capacity for overbank flooding. The long-term goal was reactivation of several old oxbows and side channels that had not seen water from high runoff in many years. Such areas would provide natural nurseries for both cottonwoods and aquatic species like the silvery minnow.

In hopes of assuring continued funding for such ecosystem restoration in the upper reach of the Middle Rio Grande, the Pueblo of Santa Ana convened a meeting with several other Middle Rio Grande tribes, the City of Albuquerque, the MRGCD, and Rio Grande Restoration (representing the Alliance for Rio Grande Heritage). The following spring, this 'Middle Rio Grande Restoration Initiative' would send a delegation to Washington, D.C. to petition for additional funds for "more comprehensive approaches to resource protection and management," including "on-the-ground and instream measures in the form of active ecosystem restoration programs and more efficient water management." Congress would answer with an appropriation of $2 million for federal fiscal years 2000 and 2001, to be disbursed through the Bureau of Reclamation for a profusion of research, mitigation, and monitoring projects.

In the summer of 1999, the Middle Rio Grande Council of Governments reported back to its member governments on Focus 2050, a long range planning project commissioned in 1996 to create a vision and strategy for managing growth and development in the region (Middle Rio Grande Council of Governments, 1999). Through a 'Futurescape' exercise presented by local high school students, regional residents were asked to select a preferred development scenario. It was assumed the region's population would increase from 710,000 to 1.5 million by the year 2050, and that the resources and infrastructure necessary to support such growth would be "in place." The favored development pattern called for infilling urban areas and placing new development on the mesas to "save agricultural lands." How sufficient water would be wrung from existing circumstances appeared to be up to local governments: a Focus 2050 spokesperson admitted that the Middle Rio Grande Council of Governments had generated the water demand for the urban sector and found "we don't have enough to accommodate 1.5 million people."

As if to mask impending scarcity, August delivered a deluge, and in the constricted river channel below Socorro, angry floodwater battered the steel undercarriage of the infamous San Marcial railroad bridge. Throughout the system, reservoirs were full and agencies were scrambling to move San Juan-Chama water around to meet prescribed evacuation schedules. In Albuquerque, the MRGCD refused to accept eight feet of water retained behind one Albuquerque Metropolitan Arroyo Flood Control Authority dam because the conservancy's ditches were already to capacity.

"The largest single obstacle to improved water management in the Rio Grande Basin is the railway bridge at San Marcial. The bed of the Rio Grande has been gradually rising for many years in the San Marcial reach. This aggrading condition has reduced the capacity of the channel at the bridge to an estimated 4,000 cfs, impeding both higher flood control releases from Cochiti Dam, and increased flows needed to improve the health of the bosque. A plan to replace the bridge is one of the principal features of the San Acacia Levee Project. The earliest that construction could begin is 2008." (Dick Kreiner, U.S. Army Corps of Engineers, personal communication, 2003.)

"In 1978, when I stood in the riverbed at San Marcial, the bottom of the railroad bridge was several feet above my head. Standing in the same place in July of 2000, the bottom of the bridge was at waist level." (Cyndie Abeyta, U.S. Fish & Wildlife Middle Rio Grande Coordinator, personal communication, 2005.)

Figure 11 a & b. *The Rio Grande at San Marcial, and the San Marcial railroad bridge (insert).* (Photos courtesy of the U.S. Fish & Wildlife Service, and Cyndie Abeyta).

In September, the City of Albuquerque filed a Complaint for Declaratory Judgement in Injunctive Relief, seeking a decision on whether the United States (in the form of the Department of the Interior) "has an interest in San Juan-Chama water" other than its diversion, storage and release to contractors; whether the contracted 48,200 acre-feet a year is the sole property of the city in perpetuity; whether the allotment must be fully consumed in the Rio Grande Basin; and whether the Bureau of Reclamation has the authority to release city-owned San Juan-Chama water from Heron Reservoir to "augment natural Rio Grande flow." In short, the city wanted to know if it was legal for San Juan-Chama contract water to be used for endangered species needs.

At what turned out to be the final Green Paper-White Paper meeting the following month, Bureau of Reclamation representatives declared it was "discouraging" to be the defendant in so many ongoing lawsuits, but also noted promise in the fact that parties to all of those proceedings were still at the collaborative table (Chris Nunn, note-taker for the Green-White Dialogue, personal communication, 1999).

Another important disagreement was also being vented that fall. Since its release in draft form a year and a half earlier, the Middle Rio Grande regional water budget had fueled a surprisingly harsh debate between the experts who had compiled it and the suddenly galvanized advocates of urban growth. By October of 1999, estimates of the region's annual water deficit had been revised downward from 70,000 to 57,000 acre-feet a year, but the amended budget also contained a brand new pie chart that assigned twenty percent of the region's depletions to evaporation at Elephant Butte Reservoir; fourteen percent to irrigation, riparian transpiration and open-water evaporation below San Acacia; eleven percent to aquifer recharge above San Acacia; nine percent to open-water evaporation above San Acacia; nineteen percent to riparian transpiration above San Acacia; fourteen percent to irrigated agriculture above San Acacia; and thirteen percent to urban consumption. Discord over those percentages would continue for the next several years.

Evapotranspiration Study

Much of the data with which planners had fashioned their tentative water pie chart had come from the early findings of an intensive investigation into bosque evapotranspiration. River seepage to the shallow aquifer is taken up by the roots of phreatophytes—water-loving species like cottonwoods, willows, New Mexico olives, Russian olives, and saltcedar—and "pulled" out of the leaves by the atmosphere. This process of transferring water from the ground to the atmosphere by plants is known as transpiration. Evapotranspiration (ET) refers to combined water loss due to transpiration and evaporation from soil and open water. How much water is lost through this process is critical in determining the water budget, or hydrologic balance, for a stream system. With a grant from the National Aeronautics and Space Administration, the University of New Mexico's Biology and Earth & Planetary Sciences Departments had undertaken a long-term study at eight sites along the river between Albuquerque and Bosque del Apache National Wildlife Refuge.

Using four sites dominated by cottonwood and four by saltcedar, and with two sites in each group receiving periodic flooding, the researchers hope to learn the costs of restoration work, and the benefit—if any—to be gained in water. Methods employed to obtain the necessary data included piezometers to gage daily fluctuations in groundwater levels; the Penman-Monteith equation, normally used to determine evapotranspiration for various farmed crops; the Bowen Ratio, which relates temperature and moisture at different levels through the tree

canopy; three-dimensional sonic anemometry to continually measure air temperature, wind speed, wind direction and humidity; and satellite remote sensing, which measures surface reflectance of light, ranging from ultraviolet to thermal infrared (i.e., temperature), and correlates special reflectance to plant properties. The study employs state-of-the-art eddy covariance to directly measure ET over the course of a complete season or year.

The data from just two years appeared to suggest that the highest ET is from densely vegetated stands, such as saltcedar thickets or cottonwood forests with a dense understory of non-native saltcedar and Russian olive; ET might be reduced one acre-foot per acre by curtailing the density of saltcedar and other vegetation; a cottonwood and grassland mosaic saves the most water; cottonwoods decline in health if the water table drops below ten feet, but such groundwater level changes do not affect saltcedars; there is a climatic response to snowpack melt and monsoons, although saltcedars tend to mask a negative response to the dry period before the monsoon season; the spring peak is identifiable each year whether water table levels go up or down; and drought stress appears to make ET losses worse. (James Cleverly, University of New Mexico Department of Biology, presentation to the Middle Rio Grande Water Assembly Action Committee, 1999.)

"The Reclamation-led interagency ET Work Group was charged not only with advancing the science and technology of measuring and monitoring daily ET demand and impacts on the hydrologic system, but they were to develop daily water management tools concurrently with the results of their research. These partnership efforts have culminated in the GIS based real-time monitoring network and decision support system maintained by the MRGCD, New Mexico State University, the National Weather Service, and the Bureau of Reclamation, and posted on the Internet for everyone's use." (Steve Hansen, U.S. Bureau of Reclamation, personal communication, 2005.)

In response to a U.S. Fish & Wildlife draft Biological Opinion issued earlier in the year regarding water operation of the Bureau of Reclamation and the Corps of Engineers, the two federal agencies filed a request asking the U.S. Fish & Wildlife Service to do the Opinion over again. At issue was what "discretionary authority" Reclamation and the Corps have to alter their assigned operations in order to restore a more natural hydrograph to or address problematic conditions in the river floodplain.

Meanwhile, attendees at the autumn Bosque Consortium meeting heard what had already become a credo among restoration advocates of the River Flow Work Group: "Within the levees," said keynote speaker Bill deBuys, "the river can perhaps be allowed to behave like a river."

But impatience and a sense of urgency still reigned among many environmentalists. In mid-November, Defenders of Wildlife, Forest Guardians, National Audubon Society, New Mexico Audubon Council, Sierra Club, and Southwest Environmental Center filed suit in federal district court to prevent further "decline of the Rio Grande ecosystem in central New Mexico." The complaint alleged that federal water managers had failed to recover the silvery minnow and the region's other endangered species, the willow flycatcher, and that the Bureau of Reclamation and the U.S. Army Corps of Engineers, as federal owners of storage and flood control reservoirs on the upper Rio Grande, had failed to use their authority to limit excessive diversions by the MRGCD or to ensure sufficient flows in the river to maintain "the biota which depend on them."

2000

To show that agencies and interest groups addressing endangered species issues were actually making progress and were committed to doing it in a united manner, ESA Workgroup participants, including the Bureau of Reclamation, the U.S. Fish & Wildlife Service, the Corps of Engineers, the New Mexico Interstate Stream Commission, New Mexico Game & Fish, the MRGCD, the Alliance for the Rio Grande Heritage, the City of Albuquerque, and the National Association of Industrial and Office Properties signed a Memorandum of Agreement to engage in efforts to cooperate in a non-litigative, ten-year recovery program for the silvery minnow and the willow flycatcher. Senator Pete Domenici had already agreed to help fund whatever collaborative could address the needs of the minnow, and there was backing from the Interstate Stream Commission as well.

In February, results of a multi-disciplinary study of groundwater resources in the Middle Rio Grande Basin were presented at a public workshop by the USGS, which had undertaken the study in conjunction with the New Mexico Bureau of Mines and Mineral Resources, the New Mexico Office of the State Engineer, the University of New Mexico, New Mexico Tech, the University of Texas at El Paso, and the New Mexico Museum. The investigations included work on the geologic and hydrologic framework of the basin, river/aquifer interactions, recharge, and improvements to computer models of basin groundwater flow. The research revealed there are "pathways" of flow within the basin; that recharge from tributary and basin-margin sources is probably significantly lower than previously thought; that recharge has been low for perhaps the last 10,000 years; that lithography and sedimentary sequences vary considerably within the basin and are influenced by local faulting; and that all of these contribute to differences in the main aquifer units of the basin (Anderholm, 2001). Revision of the groundwater flow model was aimed at "integrating the understanding of the geologic, hydrologic, and aquifer-stress components of the surface/groundwater system to provide a quantitative picture of the basin-wide aquifer system and an administrative tool for water resource management."

Although there was daily communication between water management agencies regarding flows for the silvery minnow, it was taking place amid a landscape of lawsuits and countersuits. On the plus side, URGWOM (the multi-agency water operations model) was in the process of being calibrated and reviewed; now it was time to think about how the system could be made more flexible and efficient. On March 7, a different kind of Notice of Intent was published in the Federal Register: the Bureau of Reclamation, the Corps of Engineers, and the New Mexico Interstate Stream Commission were to co-lead an agency review and conduct an Environmental Impact Statement on water operations throughout the Upper Rio Grande Basin. The review's overall objective would be to develop a plan under existing water operations authorities to (1) meet agricultural, domestic, municipal, industrial and environmental water needs; (2) meet downstream water delivery obligations; (3) provide flood and sediment control; (4) assure safe dam operations; (5) support compliance with state, federal and tribal water quality regulations; (6) increase system efficiency; and (7) support National Environmental Policy Act (NEPA) and Endangered Species Act compliance by the review's lead agencies.

A NEPA process to identify and evaluate alternatives would follow an assessment of current water operations for Platoro, Heron, Abiquiu, Cochiti, Jemez Canyon, Elephant Butte and Caballo Reservoirs; the Closed Basin Water Salvage Project; and the Low Flow Conveyance Channel. Scoping meetings began in June of 2000, with an Environmental Impact Statement expected in 2004.

In March, the Office of the State Engineer held a hearing on the proposed Campbell Ranch subdivision in the mountains east of Albuquerque. Owners of the development, anticipating some 4,000 homes, two golf courses, a business center and a resort hotel, had applied for 5,500 acre-feet of water from a deep aquifer

alleged to underlie the area. But hydrologists familiar with the region disagreed that such an underground cache existed, and the appropriation was not approved. Later, Campbell Ranch developers would request annexation to the nearby community of Edgewood in the Estancia Basin, and the question of where the water would come from would be duly transferred to local authorities.

Also that month, the Bosque Consortium and the Middle Rio Grande Bosque Initiative cosponsored a conference on "Fire in the Bosque." Since 1996, when more than 5,000 acres had burned in a single conflagration at Bosque del Apache National Wildlife Refuge and surrounding private lands, collaboration between fire suppression experts and agencies with missions along the river had become a priority. With no overbank floods to help decompose and flush woody debris from the riparian forest floor, with a dense understory of saltcedar and other exotics providing the perfect fuel ladder to a contiguous cottonwood canopy, with few patches of grass or wetland to slow fire down, and with an increasing human presence in that flammable setting, resource management agencies knew they needed a fire prevention program unlike any other. Cooperation between state, tribal, and municipal firefighters and the Middle Rio Grande Conservancy District was increasing. The MRGCD and the New Mexico State Forestry Division had even appealed to the legislature to fund a Middle Rio Grande Fuels Reduction Program. With a work force provided by the New Mexico State Forestry Inmate Work Camp, the MRGCD, Socorro's Save Our Bosque Task Force, the City of Albuquerque Open Space Division and others had already begun clearing downed wood and removing non-native trees in the bosque at particularly dangerous locations. Now they hoped to identify and map areas where research was being conducted, where special habitat existed, and where fuel reduction had already taken place. New Mexico State Forestry had plans to begin training local fire departments in tactics designed for fighting bosque blazes, and the joint agencies wanted to begin monitoring fuel and weather conditions so that patrols could be mounted in times of extreme danger. Then, too, there was increasing interest in the restoration of burn sites.

> *"We've seen in the data the effectiveness of fire awareness and prevention programs of the past four years. But I caution you to think of this only as a short-term solution, because what we really need to be doing is reversing the trend of fuel buildup." (Mary Stuever, to the Bosque Consortium Conference on Fire, March 2000.)*

One day after the Fire in the Bosque Conference, twelve miles of prime cottonwood bosque was consumed by wildfire in Valencia County. The Air Park blaze on the river's west bank was said to have moved at the hair-raising rate of three miles per hour, leaving little behind but tree skeletons and ash. The burn site would provide an opportunity for cooperative restoration. Over the next two years and with funding from the ESA Workgroup, the Corps of Engineers, the Bureau of Reclamation, and the Middle Rio Grande Conservancy District would clear forty charred acres, remove buried jetty jacks from some 6,000 feet of river bank, and lower the elevation of the cleared area to promote overbank flooding. Spoil material was employed to strengthen the adjacent levee, and the reclaimed area was replanted with native species, including cottonwood and willow. It was hoped that the $1.5 million Los Lunas Rehabilitation Project would eventually furnish not only new habitat for the Middle Rio Grande's two endangered species, but a learning lab for restorationists as well.

Figure 12. *Removing burried jetty jacks at the Los Lunas Rehabilitation Project site.* (Photo courtesy U.S. Army Corps of Engineers)

> *"There's been a lot of progress in understanding the physical processes of the river, and in what we think needs to be done to restore function. Take the jetty jacks. In 1994, if you had asked me were jetty jacks a problem, I would have thought of the jacks you see up on the floodplain and I'd have said, 'No, they're not getting any water under them' But we've become increasingly aware of the jetty jacks buried in the actual bank of the river. Is the bank able to erode and tie into the modern river hydrology, or is it frozen in place because of the jacks, Russian olives and other non-native vegetation there? We have a whole new understanding of how static the river's banks really are." (Paul Tashjian, Hydrogeologist, U.S. Fish & Wildlife Service, personal communication, 2002.)*

To help connect and provide interface for the profusion of groups and initiatives carrying out various aspects of river research and rectification, the nonprofit river advocate Rio Grande Restoration convened a Middle Rio Grande Workshop on April 11. Progress reports were heard from the Middle Rio Grande Bosque Initiative, BIG, the Rio Grande Silvery Minnow Recovery Team, the Green-White Dialogue, the Middle Rio Grande Restoration Initiative, the Bosque Consortium River Flow Work Group, the Flood Plain Work Group, the ESA Workgroup, Santa Ana Pueblo's Natural Resource Department, Albuquerque Open Space, the Albuquerque Overbank Project, the Socorro Save Our Bosque Task Force, the San Acacia & South Forum, the Bosque Ecosystem Monitoring Program, the University of New Mexico's Hydrogeoecology Program, the Middle Rio Grande Conservancy District, URGWOM and URGWOPS, the New Mexico Interstate Stream Commission's Water Supply Study Group, the Bosque Hydrology Group, and the ET Work Group. Representatives of the Six Middle Rio Grande Pueblo Coalition also attended. In a world of amplified meetings, this one made a significant impression, underscoring the enormous volume of work underway on river and ecosystem issues, and showcasing the general *bonhomie* among those who were involved in the effort.

That same day, however, Land and Water Fund of the Rockies filed a motion for preliminary injunction on behalf of Defenders of Wildlife, the National Audubon Society, the New Mexico Audubon Council, the Sierra Club, and the Southwest Environmental Center, requiring federal water managers to keep the Rio Grande wet through the difficult San Acacia reach. Corps and Reclamation personnel would now be required to give a three-day notice if "discontinuous flows" were expected in the river, and to consult with the U.S. Fish & Wildlife Service regarding all agency actions including water deliveries, reservoir operations, and operation and maintenance on irrigation diversion and conveyance facilities.

As a follow up to the Middle Rio Grande Workshop, groups involved in restoration activities were gathered again in May to explore the potential for developing a coordinated and comprehensive request for federal funding. The evolving ESA Collaborative Program included the agencies and entities that had signed on to the Memorandum of Understanding in January, but now there was concern for those outside that circle, such as the Pueblos and other community-based initiatives for whom funding through the Middle Rio Grande Restoration Initiative was no longer assured. The other funding conduit for such work—the Bosque Initiative/BIG—was temporarily minus a coordinator, and there was anxiety that important projects could fall by the wayside. The "Whole Pie Group" as it became known, sought to combine in an "annual comprehensive funding request for the Middle Rio Grande" the vast array of projects addressing Endangered Species Act compliance, silvery minnow recovery implementation, and ecosystem research, monitoring, restoration, and educational outreach. The first year, the group requested and successfully procured a budget increase for the Middle Rio Grande Bosque Initiative/BIG, bringing the total to $1 million. The following year, however, New Mexico's senior senator would demur: there were too many conflicting initiatives vying for money to accomplish similar work. In the future, Domenici advised, funding would go to just one—the ESA Collaborative Program.

Middle Rio Grande Endangered Species Act Collaborative Program

Having emerged in from the tangle of ad hoc groups attempting to deal with ESA and water management issues in the middle Rio Grande valley, the Collaborative represents the region's official endangered species program. Governed by an Interim Steering Committee made up of representatives from federal and state agencies, local water development interests, environmental groups, and the business community, the Collaborative also conducts formal government-to-government consultations between federal members of the steering committee and officials from Middle Rio Grande pueblos and tribes. Collaborative Program decisions are made by "consensus." A program coordinator housed with the U.S. Fish & Wildlife Service acts as a liaison with other ESA initiatives, distributes information, and maintains records for the program.

As is often the case with such large and inclusive collaborations, the real work happens in subcommittee. A Program Management Subcommittee and its staff carry out the directives of the Steering Committee, and are charged with developing a long-term program plan. Science Subcommittee members ensure that biological, hydrological and geomorphologic concerns are adequately addressed in the work plan, while the Habitat Restoration Subcommittee prioritizes interim habitat restoration activities and develops a long-term habitat restoration plan. The Water Acquisition and Management Subcommittee meets to address hydrologic and water supply issues, including possible sources of water for endangered species. All of the foregoing subgroups work closely together to "integrate research, monitoring, and evaluation techniques with restoration and water management actions" and to apply

"principles of adaptive management." There is also a NEPA and ESA Compliance Subcommittee, which handles required federal processes and paperwork. Two other groups have been formed to attend to public outreach and authorizing legislation.

As of 2003, the Collaborative's goals were to:

- ***Improve endangered species' status and habitat to the extent that they do not need the program:*** *Within the Middle Rio Grande Program area, act to prevent extinction, preserve reproductive integrity, improve habitat, support scientific analysis, and promote recovery of the listed species. The Program will strive to accomplish this in a manner that benefits the ecological integrity, where feasible, of the Middle Rio Grande riverine and riparian ecosystem. Actions undertaken by the Program should benefit other protected species, maintain wild populations, improve the efficiency of water use and management, and provide water to sustain the listed species. The ultimate goal of the Program is to complete activities that, along with other activities by the action agencies and interested parties, meet established criteria in the Middle Rio Grande for its contribution to de-listing of the listed species, such that the Program within the Middle Rio Grande area will no longer be necessary.*

- ***Develop agreements for water management beneficial to listed species:*** *To develop agreements with water users and water management entities that will make supplemental water available, and manage the storage and release of water in ways that contribute to the recovery of listed species.*

- ***Implement consultation under the Endangered Species Act in an effective manner to allow water development and use:*** *Implement creative and flexible options under the ESA so that existing, ongoing, and future water supply and water resource management activities and projects can continue to operate and receive necessary permits, licenses, funding, and other approvals so that the Signatories and other water users in the Program area are deemed by the U.S. Fish & Wildlife Service to be in compliance with the ESA. These water supply and water resource activities and projects include, but are not limited to, maintenance of water conveyance facilities and other actions to meet New Mexico's downstream compact obligations; flood control; legal uses of native Rio Grande water; and diversion and consumptive use of Stage I of the San Juan-Chama Project water as provided by the Colorado River and Upper Colorado River Basin Compacts for its authorized, contracted, and legal purposes, as provided by contracts and in accordance with the San Juan-Chama Project authorizing legislation.*

- ***Protect water rights, compact deliveries and other obligations:*** *Achieve recovery and water management goals in such a way that the Program does not impair valid state water rights; federal reserved water rights of individuals and entities; San Juan-Chama contractual rights; the State of New Mexico's ability to comply with interstate stream compact delivery obligations; and Indian trust assets including federal reserved Indian water rights, prior and paramount, and time immemorial water rights while exercising creativity and flexibility in order to address the needs of the listed species.*

Signatories to the Program (as of 2004) include the U.S. Fish and Wildlife Service (Region 2), U.S. Bureau of Reclamation, U.S. Bureau of Indian Affairs, U.S. Army Corps of Engineers, New Mexico Interstate Stream Commission, New Mexico Department of Game and Fish, New Mexico Environment Department, New Mexico Attorney General's Office , New Mexico Department of Agriculture, Pueblo of Sandia, Pueblo of Isleta, Middle Rio Grande Conservancy

District, City of Albuquerque, the Assessment Payers Association of the MRGCD, Rio Grande Water Rights Association, the Alliance for the Rio Grande Heritage, Rio Grande Restoration, the National Association of Industrial and Office Properties and New Mexico Farm and Livestock Bureau (Middle Rio Grande ESA Collaborative Program, 2003).

Congruent with a hot Fourth of July, the Middle Rio Grande Conservancy District received a hand-carried letter from the Bureau of Reclamation ordering operation of San Acacia Diversion Dam to maintain a continuous flow of 300 cfs for the silvery minnow. At that rate, the MRGCD water supply would be used up by the end of August. In the same letter, conservancy officials learned that the U.S. government was suddenly claiming title to the MRGCD's facilities.

Understandably, emotions were running high. On July 9, the Sunday *Albuquerque Journal* ran the following editorial:

> "The designated minnow victim is to be the MRGCD, by the unilateral determination of the Bureau of Reclamation—and MRGCD is even further instructed to make certain any water shortfall falls only on its Hispanic and Anglo farmers: 'In accordance with the United States trust obligations to the Pueblos and federal and state law regarding priority of water uses, the district's operations must be carried out in a way that pueblo water rights are not adversely affected.'
>
> *"*What a quaint mix and match of legal doctrines. If this were to be carried out in accordance with state law regarding priority of water uses, every water user in the Middle Rio Grande valley whose use started subsequent to the establishment of the MRGCD would be shut off before the priority reached MRGCD. Adios Intel, most of Albuquerque, Rio Rancho... State law would not bring the burden to the MRGCD until every junior water user had been shut off first.
>
> "The environmentalists waved this train out of the station by going to court. They exacerbated it with the motion for injunction requiring the minimum flow by force of law rather than through negotiated compromise. Now the Bureau of Reclamation has signed on to wrest water from middle valley farmers, in defiance of state law, under color of federal law, to rehabilitate the environment of the Rio Grande out of the water entitlement of a single senior group of water users.

That same week, an ideological gulf away, the environmentalists' argument was posted on the Law and Water Fund of the Rockies' website:

> "Decades of water project development, primarily by the federal government, and diversion of water from rivers for irrigation and other uses, have damaged aquatic ecosystems throughout the West...
>
> "While the federal regulatory role has expanded, federal policy is presently supportive of 'devolution', a term to suggest that federal power is increasingly shared with state, regional, and local stakeholder interests, opening doors for

> grassroots groups to collaborate with water users and others to repair the damage on a river-basin basis.
>
> "Devolution, however, is a double-edged sword. In 1995, Vice President Gore announced his Reinventing Government Initiative, [a core principle of which] is to downsize federal government, including selling or giving away federal water projects to irrigators and other traditional water project beneficiaries. On the ground, the result has been dozens of proposals to transfer ownership of federal water (and even power) projects to non-federal interests, often on terms that waive or otherwise impair the application of the ESA, NEPA, and other federal environmental laws...To the extent that environmental advocates depend on these federal laws as 'hooks' to encourage or require restoration and protection, transfers are a potential disaster."

In the days that followed, the situation boiled over. Senator Pete Domenici called the Bureau of Reclamation's action a 'nationalization' of the irrigation district and attached a threatening rider to a Senate Appropriations Bill that funded all Department of Interior programs, including those of Reclamation and the U.S. Fish & Wildlife Service. To protect New Mexico's water rights and its Rio Grande Compact interests, the Attorney General filed a brief intervening in the ongoing suit over the silvery minnow. The City of Albuquerque intervened, too, defending its 48,200 acre-feet of San Juan-Chama water against the possibility of a federal takeover. Even the Valencia County Commission passed an emergency resolution condemning the Bureau of Reclamation's claim to the works of the MRGCD, while nervous irrigators reported seeing "federal marshals" on the ditch banks, and Socorro County farmers staged an angry protest at the San Acacia Diversion Dam to keep water flowing in the Socorro Main Canal.

On the eve of a scheduled hearing in federal district court, plaintiffs, defendants, and interveners in the minnow case were ordered into mediation by Judge James Parker. After a marathon of sessions conducted under a gag order, the parties reached an agreement to take care of the fish through the end of the year. By mid-August, a Bureau of Reclamation spokesman reported to the MRGCD that the feds had managed to reduce the ensuing Agreed Order to a 'punch list' that included monitoring the critical ten-mile reach below San Acacia Diversion Dam; modifying contracts to support a "likely" continuous flow from Cochiti to Elephant Butte; assisting U.S. Fish & Wildlife in emergency fish relocation; compensating the City of Albuquerque for 65,000 acre-feet of water, and the Middle Rio Grande Conservancy District for 20,900 acre-feet; helping to coordinate the efficient delivery of the supplemental water using the MRGCD system; and procuring and maintaining ten pumps in several key locations, from above Bosque del Apache National Wildlife Refuge to Ft. Craig, to move water from the Low Flow Conveyance Channel to the river. In the longer term, a second tier of actions would involve clearing saltcedar, off-stream regulation of reservoirs, a fish passage at San Acacia, translocation of silvery minnows to the Albuquerque Aquarium, securing funds for an entrainment study, supporting water accounting and metering efforts in the MRGCD, completing a pilot channel through the river delta at Elephant Butte, obtaining reauthorization for the Low Flow Conveyance Channel, and expediting the more or less continuous consultations required by the ESA (MRGCD Board of Directors meeting minutes, August 14, 2000).

> *"The Agreed Order...provides a temporary solution that is enormously expensive in terms of the water it requires be provided for the silvery minnow. These water requirements can be met this year by partially draining reservoirs but plainly are not sustainable from the limited water supplies available to the Middle Rio Grande Valley." (State Engineer Tom Turney, Albuquerque Journal, August 2, 2000)*

Throughout 2000, the Middle Rio Grande Water Assembly continued to acquaint the public with the findings of a profusion of new investigations. Earlier in the year, the Institute for Public Policy at the University of New Mexico had conducted a statewide survey on attitudes and preferences about water issues (Brown et al., 2000). The survey included an oversample in the Middle Rio Grande, where residents ranked water for preserving the native cottonwood bosque second only to water for drinking and bathing. On-farm irrigation ranked third, slightly above water for fish, birds, and wildlife habitat. Seventy-four percent of the Middle Rio Grande respondents said they would rather keep more water in the river to protect the riparian corridor between Cochiti and Elephant Butte than to use it to promote jobs and economic development. Golf courses, swimming pools, and lawns were given the lowest ranking.

Over the course of the summer, the Water Assembly also sponsored the first round in a series of Community Conversations, asking residents in Los Lunas, Albuquerque, Rio Rancho and Bernalillo to help formulate goals and proposed objectives for a Middle Rio Grande regional water plan. 'Preserving water for a healthy Rio Grande ecosystem' was consistently high on the list of adopted goals.

By August, the Water Assembly had at its disposal a Middle Rio Grande Water Supply Study, commissioned by the New Mexico Interstate Stream Commission, funded in partnership with the U.S. Army Corps of Engineers, and performed by S.S. Papadopulos and Associates (S.S. Papadopulos & Associates, Inc., 2000). The study's conclusions were sobering:

- On average, the Middle Rio Grande's present water supply is barely adequate (including San Juan-Chama Project water and groundwater withdrawals) to meet present demands.

- The water supply as a whole, the inflow at Otowi, and the evaporation off Elephant Butte are all highly variable.

- Rio Grande Compact debt conditions can be expected to occur nearly as frequently as credit conditions.

- To maintain the water supply balance and to avoid incurring compact debt, increased water use in one sector requires reduced water use in other sectors.

- The groundwater supply is not an independent, disconnected water supply. Use of groundwater results in diminished flows of the Rio Grande that will occur in the present and continue into the future.

- The location of groundwater well fields affects short-term timing of impacts to the river; however, regardless of location, the impacts of groundwater pumping eventually reach the river and require offset.

- Recharge of groundwater from the stream system reduces the flow of the Rio Grande available to meet Rio Grande Compact obligations.

- The water supply from Otowi to Elephant Butte is essentially a single supply; water use in every subregion affects the water available to the entire region.

- Supply is only depleted by consumptive use; reductions in diversions and return flows resulting in better efficiency do not necessarily improve the water supply.

Close on the heels of the water supply study, the Office of the State Engineer issued new Administrative Area Guidelines for reviewing water right applications in the Middle Rio Grande (Office of the State Engineer, 2000). The revised rules limited aquifer mining in "critical management areas" established by the State Engineer and allowed groundwater pumping effects on the river to be figured for new permits using a state-modified version of the USGS Albuquerque basin flow model. Old pumping permits would continue to be administered under previous rules however, and the new model would be subject to revaluation in five years.

That autumn, groups involved in river restoration efforts in the "upper reach" from Cochiti to Isleta drafted a letter in response to Senator Domenici's widely-publicized proposal to relocate endangered silvery minnows north of Albuquerque:

> "As scientists and others involved in on-the-ground restoration efforts and technical studies pertaining to the Middle Rio Grande, and sponsored by government agencies, Pueblo nations, and private organizations, we share your recently-stated concerns about the need for water savings and habitat restoration along the river. Having met in a variety of forums during this particularly dry year, we now wish to propose a general plan for dealing with these two important issues. We also want to reassure you that collaborative activities addressing river issues are ongoing. They are motivated by social and environmental needs that are regional and local, by agency mandates and ESA requirements, by Rio Grande Compact requirements, and by recommendations presented in the Bosque Biological Management Plan and the Rio Grande Silvery Minnow Recovery Plan.
>
> "Before we outline the general plan, it may help to consider the following realities. First, aside from the addition of San Juan-Chama water, flows in the present and future river will, on average, not increase, and may well decrease significantly in some reaches. Second, the river's lateral movement will remain constrained mainly by the existing levee system. Third, droughts are inevitable and will limit future storage and flows of Rio Grande water.
>
> "Given these realities, meeting the objective of achieving water savings and habitat restoration along the middle Rio Grande may appear daunting. However, in the past several decades we have learned much about what is needed to sustain the vitality of the river and its bosque. Thus we know what patterns of river flow and sediment distribution affect the existence of the system's native aquatic and terrestrial plant and animal communities. We know that allowing the river to flow more naturally than it does now, by mimicking the natural hydrograph but without a net increase in average water, will improve both silvery minnow habitat and sediment distribution. More natural flows will also increase the frequency of moderate overbank flooding, which establishes and maintains native bosque trees. Moderate flooding can in addition provide food and shelter for young silvery minnows.
>
> "We, too, are aware that between Cochiti and San Antonio, the presently incised and sediment-starved river restricts conditions conducive to minnow habitat, and by inhibiting bosque inundation, promotes conditions conducive to wildfires. Bosque fires are largely human-caused and most common in dry years; their

intensity is high in thickets of saltcedar and Russian olive. Such thickets transpire excessive shallow groundwater, which has been of general concern for some time. They also armor riverbanks that seldom flood, which reduces the hydrologic connection between the river and the native vegetation in the interior cottonwood forest. Cottonwood forests that are periodically flooded inhibit saltcedar understory thickets by shading them. Such cottonwoods appear less apt to be killed by wildfire than cottonwoods that seldom get flooded.

"Taken together, the above observations imply a clear linkage between the potential for water savings and habitat restoration in and along the middle Rio Grande. In our view, therefore, management that can coordinate and implement river and bosque operations efficiently, and that simultaneously reduces the frequency and intensity of bosque wildfires, will achieve our common goals of water savings and habitat restoration. We would like to highlight actions that we think will achieve these goals:

Habitat Restoration—Implement restoration projects that prevent further channel degradation, narrowing, and incising of the river and instead create a wider, shallower, more braided river channel; develop ways to increase sediment supply to the river from Cochiti Reservoir through Albuquerque; lower elevated river bars to enable flooding during high river flows; reestablish connection of the river to the floodplain through controlled flooding to assure regeneration of cottonwoods, and to increase backwater habitat during high flows, (also essential to the prevention and overall management of bosque wildfires).

Water Savings—Remove and/or contain non-native phreatophytes, with an emphasis on saltcedar and Russian olive, which would result in reduced water consumption and decreased fire danger; focus native plant revegetation efforts on reestablishing a mosaic of habitats, including saltgrass meadows, riparian shrub communities, and stands of cottonwood/black willow, which approximate historic vegetation types and will measurably reduce water loss through evapotranspiration.

Water Quality—Study and evaluate the effects on fish populations of chlorine, ammonia, and bacterial and other pathogens from wastewater treatment facilities and sources of runoff.

Monitoring—To assure the best science, include monitoring as a fundamental component of each project.

The letter was signed by Cliff Crawford, Emeritus/Research Professor of Biology and Director of the Bosque Ecosystem Monitoring Program at the University of New Mexico; Cliff Dahm, University of New Mexico Professor of Biology; Todd Caplan, Director of the Natural Resources Department at the Pueblo of Santa Ana; Ondrea Linderoth-Hummel, President of the New Mexico Riparian Council; Michael Romero, Office of the Governor's Water Rights Committee at the Pueblo of San Felipe; William deBuys, New Mexico Community Foundation; Ross Coleman, Hydra Aquatic, Inc.; Steve Harris, Rio Grande Restoration; and Mary Stuever, Project Coordinator of the *Bosque Education Guide Update*.

A corresponding list of large-scale projects needing attention in the area between San Acacia and Elephant Butte Reservoir was produced by the San Acacia & South Forum. The list included the San Marcial railroad bridge, the San Acacia Levee project, endangered species occurrence and habitat needs in the reach, proposed realignment of the Low Flow Conveyance Channel, a Floodplain Management Plan, saltcedar control on private lands, and water delivery to Elephant Butte Reservoir.

By the fall of 2000, the Bosque Consortium's River Flow Work Group had inventoried the restoration projects underway throughout the Middle Rio Grande. The list included restoration of the active flood plain from San Antonio to the San Marcial railroad bridge; the San Marcial Habitat Restoration Mitigation Project south of the railroad bridge; restoration planning for San Antonio and south; a U.S. Bureau of Reclamation river maintenance program; the La Joya Channel Restoration Project; the Sevilleta Bosque Restoration Program; a Sevilleta National Wildlife Refuge Comprehensive Plan; habitat improvement projects at Bosque del Apache National Wildlife Refuge; New Mexico Department of Game & Fish wildlife area improvements at Bernardo, La Joya and Casa Colorado; Corps of Engineers' work in the Tiffany area; the Santa Ana Pueblo Restoration Project; a comprehensive riparian plan being developed for the Cochiti-to-San Marcial reach by the ESA Habitat Restoration subcommittee; annual projects funded and supported by the Bosque Initiative/BIG; Bureau of Reclamation plans for flood plain restoration; an incentive and conservation easement program for Socorro; the Rio Grande Riparian Forest and Riverine Restoration Initiative begun by three Middle Rio Grande pueblos; the Albuquerque Overbank Project; understory clearing work by the Save Our Bosque Task Force; fire rehabilitation and habitat enhancement work involving the MRGCD, the City of Albuquerque, and New Mexico State Forestry; exotic removal and pole planting in Rio Grande Valley State Park; and active management of the Corrales bosque.

Other relevant initiatives were the Rio Grande Silvery Minnow Recovery Plan Implementation Schedule; a ten-year Corps of Engineers river revitalization project; a sediment management study for Jemez Canyon Reservoir; an operational study for Cochiti Lake and Abiquiu Reservoir; and geomorphic restoration work in the river channel at various points throughout the region.

Meanwhile, in response to a suit initiated by Santa Fe-based Forest Guardians, U.S. District Court Judge Edwin Mechem gave the U.S. Fish & Wildlife Service 120 days to produce an environmental assessment and new critical habitat designation for the silvery minnow because the agency had not considered the "realities" of water shortage on the Rio Grande when it included the entire middle valley as home ground for the fish.

Bosque Hydrology Group Middle Rio Grande Rehabilitation Concepts

In December of 2000, members of the Bosque Hydrology Group generated what they called a conceptual framework for rehabilitation of the Middle Rio Grande. Because river geomorphology is relatively consistent for seventy-five miles between Bernalillo and Bernardo, the framework was developed with that reach in mind, though many of its tenets are applicable both upstream and down. The framework is intended to operate within the existing levees, and requires no more water than is currently available.

A 600-foot-wide channel that is disassociated from its original floodplain and frozen in place by buried jetty jacks and non-native vegetation characterizes the Albuquerque reach of the

Rio Grande. There is reduced in-channel sediment, a riparian corridor with a dense non-native understory, and accumulated woody debris. The Middle Rio Grande can never be returned to historic conditions, but the river's natural functions can be allowed to operate on a reduced scale relative to flood plain width, channel width, peak discharge, and sediment load. The following concepts are the result of a consensus process among Bosque Hydrology Group members, and are based on existing test restoration and baseline information about the historic and modern functioning of the Rio Grande.

- *In conjunction with bank lowering, remove jetty jack lines that are frozen within the banks, and non-native vegetation and associated root structures along the bank.*

- *Using strategies employed in the Albuquerque Overbank Project, implement bank lowering at a rate of 500 acres per year for the next twenty years, and return removed sediment to the river.*

- *Cut channels into existing terraces at different levels to promote better connection between river and floodplain and the natural recruitment of native vegetation.*

- *Place grade control structures at key locations to promote upstream overbanking and to control further channel incision.*

- *Increase the spring discharge peak from Cochiti Lake to promote greater connectivity between the main channel and floodplain.*

- *Reintroduce sediment using sources such as arroyos; riverbanks; Jemez, Cochiti and Galisteo Reservoirs; and MRGCD diversion structures.*

- *Remove understory exotics, deadfall, and litter to reduce water consumption and fire potential, and improve the floodplain's ability to attenuate large floods.*

- *Construct floodplain wetlands and ponds.*

- *Place woody debris from thinned areas of bosque in the river to encourage braiding, and to reintroduce organic material.*

Soon after the Bosque Hydrology Group's conceptual framework was released, its members—along with those of the "Upper Reach" and "San Acacia & South" forums—were invited to a symposium convened by the Bosque Consortium River Flow Work Group to "consider the potential for developing comprehensive restoration plans for the Middle Rio Grande." From this "Rio Caucus" emerged a vision of a scaled-down river with a natural hydrograph, more freedom to move sediment, enhanced connection to its floodplain, and more native/less exotic riparian vegetation in a closer approximation to the historic mosaic. The picture also included reduced fire danger, improved water quality, and "protected farmscapes."

Rio Caucus participants proposed a series of papers to define this "mini-Rio Grande" and to summarize what was known about (a) the river's flow history, sediment transport, geomorphology, and water quality; (b) river function relative to endangered species; (c) the limitations posed by flood control infrastructure and other constraints such as the San Marcial railroad bridge; (d) potential water savings and fire reduction through

restoration of a more natural suite of riparian vegetation; (e) the possibilities for efficiency and conservation in agricultural and urban water use; and (f) the values and benefits to be derived from river revitalization on a smaller-than-historic scale. The combined groups also acknowledged the need for and urged production of an update of the *Bosque Biological Management Plan*.

Fortunately, given the increasing interest in the health of the river corridor, the U.S. Fish and Wildlife Service had filled the vacant coordinator's position for the Bosque Initiative. Cyndie Abeyta, who had been on board since late summer, would soon revise the request for proposal requirements and the reporting process for projects funded by the program, ensuring that each related clearly to one or more of the original twenty-one recommendations for managing the Middle Rio Grande bosque.

2001

In a year when a maximum number of legislative appropriations were denied by executive veto, there were several telling exceptions. Governor Gary Johnson signed $1.5 million dollars over to the New Mexico Interstate Stream Commission for contracts with the state's water planning regions to implement "mutually negotiated and accepted scopes of work that provide for the completion of water plans in two years." He also sent $2,065,000 to the Office of the State Engineer for water management litigation and negotiation in the Pecos River and Rio Grande Basins "pursuant to federal natural resource policies." Another $2,022,000 went to continue the work of incorporating State Engineer paper archives into the now six-year-old W.A.T.E.R.S. database.

U.S. District Court Judge Edwin Mechem issued a memorandum opinion in the thirty-nine-year-old Aamodt adjudication of the Rió Pojoaque system, limiting Pueblo Indian water rights to the amount in use between 1846 and 1924. On February 18th, *Albuquerque Journal* Editorial Page Editor Bill Hume noted, "Mechem imposed a yardstick for measuring Pueblo Indian water rights, one that is considerably more constricting than the Pueblos would like." Nevertheless, Hume speculated, if Mechem's method for determining Pueblo rights survived appeal, the Six Middle Rio Grande Pueblos might be entitled to a sizeable share of middle valley water since some 23,607 acres of irrigable tribal lands existed prior to 1924.

On the environmental front, the ESA Collaborative Program offered up a draft ten-year plan to protect endangered species in the Middle Rio Grande, agreeing that there were opportunities to "improve the status of these species without impairing valid water rights, Indian trust assets, or interstate stream compact obligations." The plan called for the U.S. Fish & Wildlife Service to issue a programmatic Biological Opinion assessing Bureau of Reclamation and Corps of Engineers operations for possible impacts to endangered species. A major goal for the year 2001 was to ensure a varied genetic pool for the silvery minnow with a spike flow in late May/early June to induce spawning, followed by manual transport of minnow eggs and larvae to special refugia to be constructed at the Albuquerque Bio Park and elsewhere. Longer-range goals included habitat improvement along the river in the form of removal of non-native vegetation, some channel widening, and the creation of overbank flow areas. The plan also proposed securing water for endangered species needs through lease or purchase, and seeking approval to store it in upstream reservoirs. Projected costs of the program were thought to be $100 million, to be cost-shared on a ninety percent/ten percent basis by federal and state government.

Within a few weeks of the ESA Collaborative Program's proposal, the Rio Grande Compact Commission agreed to let New Mexico 'bank' spring runoff in Jemez Canyon and Abiquiu Reservoirs to be released over a three-year period for the silvery minnow, in exchange for 100,000 acre-feet of water in Elephant Butte. Texas reserved the right to rescind the agreement if it jeopardized compact deliveries. A formal document was signed in June, under which the federal government would pay New Mexico $4.1 million for the water, with the proceeds going to minnow refugia, habitat restoration programs, and water quality studies. The U.S. also negotiated a separate agreement with the Middle Rio Grande Conservancy District to guarantee that half of the water in the river at Isleta would actually reach San Acacia Diversion Dam. While acknowledging the actions as a step in the right direction, environmental plaintiffs in the silvery minnow case declared the agreements would neither save the species, nor derail the ongoing lawsuit.

Bosque Restoration Demonstration Project

To generate greater public awareness about the bosque and the Rio Grande through both on-site educational programs and hands-on community participation in restoration activities, the Bosque Restoration Demonstration Project was launched in the spring of 2001 by the river advocacy group Rio Grande Restoration, and the City of Albuquerque Open Space Division, with support from the Middle Rio Grande Conservancy District Board of Directors. Funding for the project was provided by the Bosque Initiative/BIG, and through the efforts of the Middle Rio Grande Restoration Initiative.

The initial restoration site—five-acres on the east side of the river along Tingley Drive in Albuquerque, about one-half mile south of Central Avenue—was chosen for its public visibility and community access. Inmate work crews, under the direction of the New Mexico State Forestry Division of the Energy, Minerals, and Natural Resources Department, were contracted to remove non-native invasive plant species. Volunteers were also enlisted by City Open Space and Rio Grande Restoration. Church and school groups, scout troops, neighborhood families, and others participated in restoration activities, including pole planting, trash cleanup, removal of dead and down material, and mulch distribution. Each year of the project, Lafarge, Inc. removed building debris that historically had been dumped in the bosque as fill to reinforce the levees.

During the third year, the site was expanded to ten acres. Much of the work was again contracted to inmate work crews, with the additional help of volunteers, who assisted in the removal of two east-west lines of jetty jacks. Revegetation was curtailed, however, due to drought conditions. Signage, an information kiosk, and limited trail markers and benches are proposed to complete the project. Albuquerque Open Space will oversee future site maintenance and monitoring.

Even in its early stages, the Bosque Restoration Demonstration Project was used as a teaching site. Designed to dramatically portray the contrast between an overgrown and unhealthy bosque and a restored site, the project provided an immediate consciousness-raising experience for visitors. Rio Grande Restoration has led tours on an annual basis for Leadership Albuquerque, and arranged periodic visits for public officials and others in the community. Albuquerque Open Space staff routinely use the site for ongoing educational programs, and the location is referenced in the Bosque Education Guide as a place for instructional opportunities. (Deb Hibbard, Middle Valley Program Coordinator, Rio Grande Restoration, 2003.)

In June, the City of Albuquerque applied to the Office of the State Engineer for a permit to divert up to 48,200 acre-feet of San Juan-Chama water plus an equal amount of native Rio Grande water from the river at an unspecified location north of the city. Under the proposed Drinking Water Project, peak diversions of up to 103,000 acre-feet per year would be taken from the river and treated for municipal use. The native water would then be returned to the river as treated effluent at Albuquerque's wastewater plant some miles downstream. Protests of the application were subsequently filed by the Navajo Nation, the San Juan Water Commission, the community of Bloomfield, the Middle Rio Grande Conservancy District, the Pueblo of Isleta, a number of private citizens, and a coalition of agricultural and environmental interests. The diversion, protestants charged, would infringe on existing water rights, diminish the overall water supply for downstream users, jeopardize riparian habitat, impact water quality, and interfere with the state's ability to meet its Rio Grande Compact obligations.

> *"The Middle Rio Grande water budget reflects changes in hydrology, riparian ecology and groundwater pumping. Major depletions include urban uses, irrigation, plant transpiration, open water evaporation, and aquifer recharge. The largest are open water evaporation and riparian plant transpiration. Irrigated agriculture accounts for an estimated twenty percent; urban consumption and net aquifer recharge account for twenty to twenty-five percent, each. Even with inflows from San Juan-Chama and municipal wastewater discharge, which constitute extra water in the system, water depletions are already fully appropriated for an average year. Municipal use of San Juan-Chama water, sustained drought, and continued growth will increase pressure on surface water resources." (Water In A Changing World, Jackson et al., 2001.)*

Midsummer, the U.S. Fish & Wildlife Service released the Programmatic Biological Opinion (U.S. Fish & Wildlife Service, 2001) on the effects of proposed federal and non-federal water management actions in the Middle Rio Grande. The Opinion, valid through December of 2003, included a Reasonable and Prudent Alternative of year-round flows from Cochiti to below Isleta; not less than 100 cfs at Isleta; a target flow of 50 cfs at San Marcial between July 1 and October 31; if necessary, a spike flow between April 15 and June 15 each year to induce silvery minnow spawning; supplemental water releases when possible; a cost-shared captive minnow propagation program; the reintroduction of silvery minnow populations in the upper reaches of the river; pumping from the Low Flow Conveyance Channel to augment intermittent river flows below San Acacia; a fish passage at San Acacia Diversion Dam; the continuation of habitat restoration work in the Middle Rio Grande; the relocation of the San Marcial railroad bridge to increase channel capacity; and overbank flooding to create backwater habitat whenever conditions would allow.

Nearly simultaneously, the U.S. Fish & Wildlife Service produced a plan to "protect, restore and maintain viable levels of biotic diversity within the Upper/Middle Rio Grande Ecosystem" (written communication, U.S. Fish & Wildlife Service, 2001). The plan acknowledged the need to 'mesh' ecosystem priorities, goals and objectives with the activities of other resource management agencies in order to achieve the greatest gains for fish and wildlife. Sustainability, the plan suggested, rests on 1) restoring threatened and endangered species and their habitats; 2) maintaining migratory bird populations at healthy levels; 3) reversing declining trends in quality and quantity of riparian and wetland habitats, and restoring the species composition, aerial extent, and spatial distribution of riparian/wetland habitats; 4) protecting, restoring, and maintaining native fish and aquatic communities, and promoting sport fisheries management where native fish and other aquatic organisms are not adversely affected; 5) restoring upland terrestrial communities at the landscape level; 6) interpreting the link between healthy, stable ecosystems and human/community health; and 7) protecting and

enhancing water quality and quantities for aquatic, wetland, and riparian habitat. Objectives and actions items for each of thirteen U.S. Fish & Wildlife Service offices in the Upper/Middle Rio Grande were also set out in the plan.

The Bosque Hydrology Group meanwhile had defined five sub-reaches of the river from the confluence of the Rio Puerco to the headwaters of Elephant Butte (Tashjian, 2001). About half of the eighty-nine mile length, including the San Acacia-to-San Marcial silvery minnow battleground, was about to be the site of a major restoration and rehabilitation program spearheaded by the Save Our Bosque Task Force. Understanding the nature of the sub-reaches was critical to developing a rehabilitation plan because each river segment had defining characteristics and a differing set of circumstances. When current conditions were assessed, it was found that unlike much of the system to the north, there was for the most part an active connection between the river channel and its floodplain; the bosque still experienced overbank flooding in many places; the main channel was generally wide with an active, sand bed; the floodplain was constantly being eroded and reworked; and the mosaic of riparian vegetation was more open, with a greater grassland component than in areas upstream. But there were problems, too. The river was sediment-starved below San Acacia Dam, there were several specific limits to the passage of high flows, and the entire region was infested with non-native saltcedar. The Bosque Hydrology Group listed primary concerns and restoration concepts for each sub-reach, and proposed a toolbox of conceptual rehabilitation designs for the overall Socorro area that included:

- Inducing artificial avulsion by clearing channel paths through the floodplain, with mechanical redirection of the active channel into desired new channels

- Clearing vegetation from sandbars, especially in low runoff years, to encourage bar mobility and to prevent armoring

- Destabilizing banks by removing non-native vegetation and associated root structures

- Reducing the height of the riverbank where possible and returning the removed sediment to the river

- Cutting channels through different levels of the river terrace to promote better connection with the floodplain, and improving natural recruitment of native vegetation

- Maintaining channel width by removing non-native vegetation, controlling sandbars, plowing bank sediment into the river, and establishing a collaborative program of conservation easements with private landowners

- Managing exotic species

- Placing grade control facilities at key locations to promote upstream overbanking and to dissuade further incision of the channel

- Managing livestock grazing

- Increasing the spring peak discharge from Cochiti to promote connectivity between the main channel and the floodplain

- Promoting the establishment of native plant species

- Carving secondary channels into the floodplain that would be active during various high flows

- Seeking out sources of sediment to be returned to the system

- Removing non-native understory, deadfall, and litter from the bosque to reduce water consumption and fire potential, improve the ability of the floodplain to attenuate large floods, and promote general forest health

- Adding woody debris from forest-thinning to the river to promote braiding and return organic material to the channel

The same stretch of river had been on the U.S. Army Corps of Engineers' docket for levee construction and rehabilitation for some years. Endangered species issues had stalled the project, however, and by 2000, the Corps was proposing a reduced scope of work that included building levees to protect the City of Socorro and Bosque del Apache National Wildlife Refuge, and raising the problematic San Marcial railroad bridge.

San Acacia-to-San Marcial Conceptual Restoration Plan

To consolidate current restoration and rehabilitation initiatives as well as existing biotic and abiotic information for the active floodplain between San Acacia and San Marcial, Socorro's Save Our Bosque Task Force developed a comprehensive plan for the reach.

The plan's basic assumption is that general habitat types are associated with the surface water available from river flows. Since the goals of the plan are increased habitat diversity and restored river processes, implementation would establish a mosaic of wetlands, forests, savannas and grasslands that formerly existed in the floodplain.

Plan products include Geographic Information System maps showing flooding potential, major vegetation types, the river's vegetated bank line, restoration techniques, streets and highways, political subdivisions, and private land designation.

A review of historical maps and aerial photographs was made to determine what changes have taken place over time in the composition and acreage of various vegetative communities, and in the amount of open water and wetlands. Streambed location, river channel characteristics, floodplain geomorphology, levee features and other elements of the floodplain are indicated on the GIS maps. A historic hydrograph, along with below and above average hydrographs of the reach, were developed using stream gage data from several governmental agencies. Data used in the analysis comes from "hydrologic and geomorphologic studies and reports, current water budget information for vegetation and open water, vegetation classifications and mapping, analysis on stream bed characteristics, analysis of flood plain terraces, seepage runs, restoration design research, and examples of specific restoration techniques." The conceptual restoration document also notes gaps in existing data and recommends programs to fill them.

A complete geomorphic analysis of the river channel through the study area was performed to assess channel slope, aggradation/degradation, bed load, geologic influences and controls,

and feasibility of overbank flooding. Sub-reaches were differentiated and analyzed, making use of ongoing work by the Bureau of Reclamation and the Bosque Hydrology Group wherever possible. Restricted channel capacity, high flood hazard, habitat and species issues, compact delivery impediments, and water savings potential were noted for each sub-reach. Areas of "unsatisfactory river condition" were identified, "likely, remote, and unlikely causes" for the condition were assessed, a trend analysis for the reach's physical characteristics was determined, and the most important factors for restoration were proposed.

The plan recommends river enhancement strategies and alternatives for each sub-reach, and determines scientific parameters upon which a monitoring program can be based once rehabilitation is implemented. Project maintenance needs were examined, existing land use policies reviewed to determine where changes might be needed, and all private landowners were welcomed to participate in the plan preparation process. An oversight committee comprised of project members and local stakeholders were given the role of guiding, reviewing and commenting on the plan. The committee operated on a consensus basis, and all comments received were accorded equal weight in the evaluation process.

In the summer of 2001, U.S. District Judge James Parker issued a Memorandum Opinion and Order in the silvery minnow case, concluding that the "national policy of saving endangered species has priority over even the primary missions of federal agencies," and that the Bureau of Reclamation has "discretion" over native water delivered to the Middle Rio Grande Conservancy District, as well as over deliveries of San Juan-Chama water to individual contractors. The ruling was apparently intended to convey the notion that everyone in the Middle Rio Grande should share the burden of supplying water for the minnow.

Federal monies continued to be appropriated for projects in the Middle Rio Grande. The ESA Collaborative Program sent out a request for proposals to address the 2001 Biological Opinion and Reasonable and Prudent Alternative. Federal funds were also requested for Santa Ana Pueblo's multi-year program to amend river function and create riparian habitat for the minnow and the willow flycatcher; the Pueblo of Sandia's ongoing water quality monitoring efforts, analysis of the irrigation system to identify efficiency improvements, and bosque restoration pilot project expansion; the University of New Mexico's Bosque Ecosystem Monitoring Program, and continuation of the bosque ET monitoring program; BIG's seven research, six monitoring, fifteen habitat, and seven outreach projects; bosque fuel reduction work by the Socorro Save Our Bosque Task Force; wetland and riparian restoration, including treatment and removal of saltcedar at Bosque del Apache National Wildlife Refuge; U. S. Department of Agriculture Forest Service Rocky Mountain Research Station studies of the effects of fuel reduction and exotic plant removal on vertebrates, vegetation, and water resources in the bosque; a U.S. Fish & Wildlife Service assessment of the silvery minnow wild population; Partners for Wildlife work on private lands in the Middle Rio Grande watershed; and a New Mexico Ecological Services Field Office assessment of water quality in silvery minnow habitats in the Middle Rio Grande.

Water Quality and the Silvery Minnow

In September 2001, the U.S. Fish and Wildlife Service initiated the multi-year study, "Water-quality Assessment in Relation to Rio Grande Silvery Minnow Habitats within the Middle Rio Grande, New Mexico." The project's primary purposes were to (1) determine the potential

nature, role and extent of water-quality degradation in the population decline of the silvery minnow; and (2) assess the species' water-quality needs. In designing the project, historic water-quality data were reviewed to assess data needs.

Field-sampling activities were conducted between July 2002 and February 2003. The sampling events occurred two to four times per year at eleven sites located in the main stem of the Rio Grande from north Albuquerque to the north boundary of Bosque del Apache National Wildlife Refuge; two sites at wastewater treatment plant outfalls to the Rio Grande (Albuquerque and Rio Rancho), and one site at the lower San Juan irrigation drain return, where agricultural runoff is reintroduced to the river. Chemical analyses were conducted on water, sediment, and fish tissue samples, and health assessments were conducted on live fish collected at sampling sites. Analytical results were released in the draft report, "Water-quality Assessment in Relation to Rio Grande Silvery Minnow Habitats within the Middle Rio Grande, New Mexico," (Abeyta and Lusk, 2004).

Additional water, sediment, and fish sampling and analysis were conducted in 2004 at the City of Albuquerque Rio Grande Silvery Minnow Naturalized Refugia, the U.S. Fish and Wildlife Service/Fisheries Resource Office silvery minnow holding facility, and in response to a fish kill due to overbank flooding of the Rio Grande at the powerline crossing south of San Marcial. Surface-water and sediment samples were also collected and analyzed in response to an oil spill in the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) South Channel, and ground-water samples were collected from and analyzed for the Rio Rancho/Willow Creek bosque mortality site. The U.S. Fish and Wildlife Service is scheduled to release these data in an upcoming report.

In conjunction with the aforementioned study, the U.S. Fish and Wildlife Service and the U.S. Geological Survey/Biological Resources Division conducted acute and chronic toxicity tests on silvery minnow with river water, effluents, irrigation drain return water, ammonia, and ash from a recent bosque fire. Information collected through the water-quality and toxicity studies will be used to identify impacts on silvery minnow habitat due to natural and anthropologic activities; understand the water-quality needs of the silvery minnow; characterize water-quality conditions in various habitat types in different geomorphic reaches of the Middle Rio Grande; guide future toxicity studies and water-quality monitoring as they relate to silvery minnow health and habitat; provide water management agencies with information for making water management decisions; plan for recovery and reintroduction of silvery minnow; and evaluate location for proposed river restoration projects. (Cynthia G. Abeyta, Hydrologist/Middle Rio Grande Coordinator, U.S. Fish & Wildlife Service, 2004.)

Figure 13. *U.S. Fish & Wildlife Service personnel collect water quality data at Albuquerque's Wastewater Treatment Plant outfall*. (Photo courtesy U.S. Fish & Wildlife Service)

Autumn saw an unhappy consequence of the previous summer's agreement to store water for the silvery minnow at Jemez Canyon Reservoir. Some 8,000 acre-feet had been released by the Corps of Engineers to augment dwindling flows in the Rio Grande, and now, migrating sandhill cranes mistook the glistening ooze of the drained reservoir for open water. When a few dozen of the birds died mired in the sticky sediment, it was front-page weekend news (*Albuquerque Journal, November 10, 2001).*

Also that fall, Rio Rancho became the first municipality in the state to have to secure up front the surface water rights to offset a proposed increase in groundwater withdrawal. Prior to the new rule set forth in the Middle Rio Grande Administrative Area Guidelines, entities had been granted a conditional pumping permit based on a promise to acquire the necessary rights in the future, when effects on the river became apparent. The practice, known as "dedication," allowed the State Engineer to grant a well permit for a municipal system, mutual domestic, or new subdivision without knowing where the offset water would come from. Now, New Mexico's fastest-growing city would be the first to feel the sting of the amended policy.

Another practice ripe for change was the mandate regarding domestic wells. Statute required the State Engineer to issue domestic well permits upon request, but at the rate of several thousand per year, the collective impacts of pumping three acre-feet per well annually had the potential to eventually affect surface flows. Measures to deal with the problem had repeatedly been brought before lawmakers and summarily defeated. Now, the legislative interim committee on Water and Natural Resources had recommended giving the State Engineer the power to restrict the number of wells or the amount of water they produced in areas of severe aquifer drawdown, or where increased water use might cause New Mexico to violate the terms of an interstate compact. Once again, legislation was being drafted to that effect.

Bosque rejuvenation was already happening with a lighter touch at Sandia Pueblo. Since the fall of 2000, riparian exotics were being removed at a sure and steady pace using manpower rather than an excess of heavy equipment. The tribe's intent was to recreate a bosque more like the one that Sandia's elders recalled from childhood: scattered groves of canopy cottonwoods with grasslands in between, and a sparse but useful understory of willow and native olive. To return the forest to that condition without further degrading the environment, pueblo work crews methodically targeted non-native trees, cut the trunks into firewood lengths for delivery to community members, ground up the stumps, and shredded the smaller limbs to be used as mulch in pole planting new cottonwoods. Plantings were placed with their roots in the water table to ensure survival. As of 2004, some 120 acres of bosque had been restored, including a twelve-acre burn site previously overtaken by saltcedar.

2002

The minimum flow agreement with the Middle Rio Grande Conservancy District that had helped the City of Albuquerque meet Clean Water Act standards for a decade had expired in December of 2001. Now it was renegotiated to serve a dual purpose. The MRGCD would maintain a minimum flow of 150 cfs through the Albuquerque reach. Downstream of the city's wastewater treatment facility, the flow would dilute effluent to satisfy EPA and Isleta tribal requirements. Above the plant, it would quietly help mitigate the impacts on the riparian corridor of the city's planned diversion of San Juan-Chama water.

> *"Although New Mexico has just recently begun investigating the technical viability of active groundwater recharge projects, "incidental" recharge [seepage from*

water delivery systems] has been a significant source of groundwater replenishment for many decades. For example, a 1994 study by the U.S. Bureau of Reclamation concluded that the irrigation works of the Middle Rio Grande Conservancy District contributes up to 30,000 acre-feet per year of recharge to the groundwater aquifer that is relied on by the City of Albuquerque for its municipal water supply." (Tessa T. Davidson, "Groundwater Recharge: The Legal Realities of Keeping the System Whole," 1998.)

In March, the World Wildlife Fund and the Alliance for Rio Grande Heritage sponsored a three-day Restoration Vision Workshop. Some fifty biologists, ecologists, hydrologists, geomorphologists, restoration practitioners, and conservation advocates from local, state, and federal agencies in the U.S. and Mexico focused on bioregional ecosystem issues. They considered five questions: (1) What are the distinct biodiversity features that constitute a functional Rio Grande ecosystem? (2) What are the abiotic/biotic processes required to preserve and restore these biodiversity features? (3) Based on the previous information, how do we best define restoration goals for the Rio Grande? (4) What are the constraints and opportunities for attaining these goals? (5) How could we best achieve these goals, both within existing constraints and under a far-reaching vision for ecosystem restoration? The goal of the Restoration Vision project, "born out of the recognition of the wealth of expertise that currently exists on the Rio Grande," was to develop a conceptual framework for system-wide restoration of hydrologic and biologic processes that sustain the Rio Grande ecosystem, and to do it from a holistic, synergistic standpoint to provide a link between the river's several bioregions. An extensive report on the project, called *Hope For A Living River,* was contracted to Tetra Tech, Inc. (Fullerton and Bates, 2003). In a list of recommendations for "realizing the restoration of the Rio Grande," the report called for a public awareness and education campaign on the value of the Rio Grande ecosystem. "It is not a coincidence," the authors conclude, "that the area with the most restoration activity, the Middle Rio Grande Valley, is also the area where restoration issues such as preservation of the bosque and endangered species are common knowledge and important to many people."

The following month, the Bureau of Reclamation reported there were "weak spots" in the Rio Grande levee system. One contributing factor, some believed, was that routine floodway maintenance had not been performed since the litigious year of 1996. Instead, vegetated islands and bars had been allowed to form in the river channel, forcing the main current against the levees in certain places. Exactly where the twenty-five vulnerable points were was not made public (MRGCD Board of Directors meeting minutes, April 8, 2002).

Participants in the ESA Collaborative Program signed a second Memorandum of Understanding, reaffirming their intent to help recover the region's two endangered species and conserve their habitats without jeopardizing Rio Grande Compact obligations, state water law, federal commitments to Native American tribes, or water projects being planned by the City of Albuquerque. Signatories included the Bureau of Reclamation, U. S. Fish & Wildlife Service, the Corps of Engineers, the Bureau of Indian Affairs, the New Mexico Interstate Stream Commission, the City of Albuquerque, the MRGCD, the Alliance for the Rio Grande Heritage, the National Association of Industrial and Office Properties, the New Mexico Environment Department, the New Mexico Department of Agriculture, Rio Grande Restoration, the University of New Mexico, New Mexico State University, and Bernalillo County Farm Bureau. An Interim Steering Committee was tasked with finalizing the Collaborative Program's governance structure and organizing a number of working subcommittees. Government-to-government consultations with Pueblos and tribes also continued.

On April 20, Chief U.S. District Court Judge James Parker upheld U.S. Fish & Wildlife's 2001 Biological Opinion (U.S. Fish & Wildlife Service, 2001) establishing minimum flows for the silvery minnow, and allowing for intermittent drying of the reach below San Acacia Diversion Dam. Noting that the Opinion

balanced flow requirements with other protective measures such as the construction of a fish passage at San Acacia, habitat restoration, and re-population of silvery minnows upstream, Parker believed the Opinion should stand. On a more controversial issue, he also reaffirmed that the Bureau of Reclamation has the discretion to "limit water deliveries to the Middle Rio Grande Conservancy District," and to "supply less water to San Juan-Chama contractors in order to meet fish and wildlife needs." Parker acknowledged the collaborative process underway to save the minnow, saying, "I do not wish to upset, without strong justification, agreements the United States has entered into with the State of New Mexico and the MRGCD...The overall effect of my decision will be that when the parties go back to the table [for another round of consultation with U.S. Fish & Wildlife] the annual water deliveries I have identified as discretionary will be available to be considered for use in protecting the silvery minnow from extinction." The State of New Mexico, the City of Albuquerque, and the Middle Rio Grande Conservancy District would appeal the ruling.

> *"Streamflow through the middle valley for minnow habitat also fulfills the necessity of delivering water downstream to Texas and Mexico, as required by the Rio Grande Compact. This characteristic [of the "fight between minnow and human use of water"] provides rich middle ground for compromise and accommodation." (Albuquerque Journal editorial, April 23, 2002.)*

A Legislative Finance Committee Performance Audit of the New Mexico Office of the State Engineer and the New Mexico Interstate Stream Commission, posted on the State Engineer's web page at the end of April, 2002, revealed the sister agencies (a) had inadequate strategic plans for effective administration, (b) had no long-term solution for delivering water in accordance with compacts, and (c) that there were no statutory sanctions or incentives to promote regional water planning; (d) that W.A.T.E.R.S., the comprehensive Office of the State Engineer database, was not yet fully populated or adequately reviewed for quality control; (e) that the backlog of water right applications had still not been adequately addressed; and (f) that the combined agencies' system of monitoring contractual performance did not ensure that dollars spent achieved desired results. On the plus side, never before had members of the public had such easy access to so much water information, including OSE well reports, pending subdivision permits, and cached forms for filing water right declarations.

By May 1st, reservoirs statewide were at their lowest levels in twenty years, and the runoff forecast was one of the worst in forty-five years. The media suddenly awakened to the story: KOAT-TV offered "complete coverage of the drought" on the nightly news.

Also that month, the City of Albuquerque issued a final report (CH2MHill, 2002) on the hydrologic effects of its proposed Drinking Water Project. The report concluded that a 'No Action' alternative, based on groundwater pumping to meet all the city's future needs, would have a larger effect on aquifer drawdowns than would the diversion of San Juan-Chama water from the river for direct municipal use. The report also noted that under the 'No Action' option, Office of the State Engineer Critical Management Area Guidelines for the east side of Albuquerque would be violated, and a potential seventy-four square miles of land could be subjected to surface subsidence. The Drinking Water Project, the report maintained, reduced the subsidence risk to an area of about six square miles. Net effects on the river were on the order of 30,000 acre-feet a year by the year 2060 under the 'No Action' alternative. Under the Drinking Water Project, such effects "are never more than the city's vested and acquired water right of 23,347 acre-feet a year in early project years, and decline to about 10,000 acre-feet a year in 2060." The report did note that with the advent of the project, river flows below the diversion would be 45 cfs lower than under the 'No Action' alternative.

At the sixth Annual Middle Rio Grande Water Assembly in June, constituency groups representing water managers; specialists; urban and economic development interests; environmentalists; and agricultural,

cultural and historic advocates demonstrated their preferred scenarios for balancing the regional water budget using a computer model under development by Sandia National Laboratory. Each of the groups considered reducing evaporation from Elephant Butte Reservoir as a viable means of balancing the budget; other measures included reducing per capita residential use, and ridding riparian areas of non-native vegetation. All five constituencies were able to achieve a tenuous water budget balance, but all found such equilibrium to be short-lived if population growth continues.

> *"Population increases in the basin since the 1940s have caused dramatic increases in groundwater withdrawals from the aquifer system, resulting in large groundwater-level declines. Because the Rio Grande is hydraulically connected to the aquifer system, these groundwater withdrawals have also decreased flow in the Rio Grande." ("Simulation of Ground-water Flow in the Middle Rio Grande Basin Between Cochiti and San Acacia, New Mexico," McAda and Berroll, 2002.)*

In mid-May, the Bosque Initiative/BIG held a two-day conference at the National Hispanic Cultural Center of New Mexico, in Albuquerque. There were panel presentations on research, restoration/fuels reduction, and educational outreach activities in the Middle Rio Grande, and guided field visits to the Jardines del Bosque Research Station; Sandia Pueblo Restoration Project; San Antonio Oxbow Project; Bosque Restoration Demonstration Project; and Los Lunas River Park Project.

The Bosque Initiative's newly-created website was also unveiled. The site (*http://mrgbi.fws.gov*) would eventually offer a history of the Bosque Initiative/BIG; the complete Bosque Biological Management Plan; maps of the Rio Grande watershed and river reach maps showing Bosque Initiative project locations; Bosque Initiative grant information and the annual Request for Proposals with on-line submission capabilities; a list of Bosque Initiative funded projects with descriptions; hyperlinks to separate project pages; an extensive media reference page; links to all pertinent agencies; resources including books, reports, fact sheets, etc.; and a list of other funding sources.

Figure 14. *Students from the Jardines del Bosque Research Station at work in the river near the National Hispanic Cultural Center in Albuquerque*. (Photo courtesy of Cyndie Abeyta)

On June 6, a proposed rule to designate critical habitat for the silvery minnow was published in the *Federal Register*. (Federal Register, 2002.) The 'final' critical habitat designation made in 1999 had been set aside by court order; the new one acknowledged that "habitat quality within the mainstem river channels in the historical range of the silvery minnow is intrinsically related to the character of the floodplain and the associated tributaries, side channels, and backwater habitats that contribute to the key habitat features (*e.g*., substrate, water quality and water quantity) in the middle Rio Grande." In framing the designation, the *Register* referenced the findings of the "Biological Interagency Team" that had authored the 1993 *Middle Rio Grande Bosque Biological Management Plan*.

Meanwhile, water managers were again confronting the realities of trying to keep the river wet for minnows during a drought. Middle Rio Grande Conservancy District farmers were bracing for a truncated irrigation season when it was announced that an agreement had been negotiated with the City of Albuquerque: in exchange for dropping its protest of the city's proposed Drinking Water Project, the MRGCD would receive 70,000 acre-feet of Albuquerque San Juan-Chama water to see irrigators through most of the season. Under terms of the agreement, the MRGCD assumed several key duties. First, it would provide a minimum flow for the silvery minnow "consistent with the applicable Biological Opinion." The borrowed water would not be subject to the jurisdiction of the Bureau of Reclamation. Payback of the loan was due within fifteen years of the advent of the city's Drinking Water Project, and the repayment terms further finessed solutions for two other city problems: offsetting the effects of its groundwater pumping on the aquifer, and diluting effluent to meet its NPDES permit. In low water years, the city would lend the MRGCD another 20,000 acre-feet of San Juan-Chama water; in return, the district would provide an equal amount of repayment water "for use in a city aquifer recharge program, storage program, or other use as required by the city." The MRGCD withdrew its protest of the Drinking Water Project a few weeks later, and the Office of the State Engineer dismissed the agency as a protestant in the suit, never having seen the pertinent settlement agreement.

A review of published and unpublished literature and data on the geomorphology and sedimentology of the Rio Grande between Cochiti Dam and Elephant Butte was submitted to the New Mexico Interstate Stream Commission in June (Mussetter Engineering, 2002). An evaluation of historic and present-day characteristics of the river, the natural and human-induced factors controlling those characteristics, and current opinions on the cause of incision, channel narrowing, etc., led the project's consultants to conclude "there is a real possibility for confusion regarding cause(s) and effect(s)."

Under contract with the Bureau of Reclamation, fish expert Piotr Parasiewicz of Cornell University was examining the feasibility of constructing a 'nature-like' fish passage facility at San Acacia Dam, just up reach from the last wild population of endangered silvery minnows. In his final assessment, Parasiewicz noted that the river's hydrological and morphological dynamics have been "purposely undercut" by modifications to its channel, and that unless a restoration of the entire ecosystem is undertaken based on an integrative watershed study that includes both ecological and socioeconomic aspects of river management, neither the installation of a fish passage nor even complete removal of San Acacia Dam could ensure recovery of the silvery minnow.

> *"A long term management plan must incorporate the ecological as well as socio-economical aspects of river management. Building upon a comprehensive, interdisciplinary ecosystem study, this management concept should define the measures that are necessary for restoration of the entire ecosystem." (Consultation on a Fish Passage at San Acacia Diversion Dam, Piotr Parasiewicz, written communication, 2002.)*

In early July, a NEPA hearing was held on the Draft Environmental Impact Statement prepared by the Bureau of Reclamation on Albuquerque's proposed Drinking Water Project. The majority of speakers expressed concern over the unusual speed at which the NEPA process was being carried out, and noted troubling omissions and discrepancies in the draft EIS. Among other things, no Biological Assessment had been included; loss rates for delivery of San Juan-Chama water between Cochiti and the unnamed diversion point had not been approved by the Rio Grande Compact Commission; the 'preferred alternative' of an inflatable diversion dam across the Rio Grande had not been one of the thirty-two original alternatives evaluated by the city or ranked by the public, and its design included no fish passage for the silvery minnow; the plan contained no credible municipal water conservation or recycled wastewater component; no provisions were made to protect riverine ecology from depletion effects between the diversion and return flow points; historic demands for water below Angostura Diversion Dam were not truly reflected in the city's diversion and curtailment strategy; the aquifer storage and recovery component of the plan had not yet been designed; and analysis of the project's impacts were based on annual averages, not on daily flow data.

A report entitled, "*Water Fuels Sprawl: An Analysis of Water Transactions and Inefficient Growth in New Mexico*," (Coyne and Bassett, 2002) was released in July by the New Mexico Public Interest Research Group. The publication recommended that in order to "put urban growth on a sustainable course and reduce the demand for water transfers and their corresponding impacts," the state would need to (1) connect growth management planning and water planning; (2) make urban conservation the focus of urban water management to reduce the need for water transfers; and (3) prevent the impacts of water transfers on third parties and make the transfer approval process more democratic. The report called for municipal and county approval of only those development projects that are compatible with regional water budgets; a per-person-per-day usage of 150 gallons or less by the year 2010; and the required consent of irrigation districts, water user associations, and rural communities before water transfers are approved.

Another publication, this one authored by three divergent voices from local water circles, also caused a stir that summer. "*Taking Charge of Our Water Destiny: A Water Management Policy Guide for New Mexico In the 21st Century,"* (Belin et al., 2002) made some astute observations about the state's increasing predicament regarding its finite ground and surface water supplies. The trio took on all of the hot topics: an 'outmoded' priority water rights system; the near-nonexistent link between land use planning and water availability; the statewide pillage of nonrenewable groundwater; the sacrifice of rural communities to urban growth; and the proliferation of lifestyles inappropriate to a semiarid environment. After comprehensive suggestions about what state and local agencies might do to remedy these situations, the authors appealed to the general public: "If we are to move toward a future where shared values are protected, New Mexicans will need to take a number of steps. First, we must all become more knowledgeable about water in our state. Second, we will need to become more involved in decision-making and planning. Third, the public needs to make its voice heard. The legislature, the State Engineer, local officials and others are more likely to support change if there is support among their constituencies."

> *"We passively but inexorably allow the future of our state to be determined by the day-to-day operation of outmoded laws, policies, and regulations relating to water." (Taking Charge of Our Water Destiny, Belin et al., 2002)*

As August began, the U.S. Army Corps of Engineers began a series of scoping meetings to solicit input on its Middle Rio Grande Ecosystem Restoration Project (U.S. Army Corps of Engineers, 2003) for "restoration of the bosque into an ecologically sustainable natural environment." The project, initiated in 2001 by Senator Pete Domenici and assigned to the Corps, aims to both restore a functioning bosque ecosystem and

generate greater public awareness through educational and interpretive features and increased access to the bosque. The large scale reconnaissance study encompassed the bosque between the North and South Diversion Channels, from the Pueblo of Sandia's southern boundary to Isleta. The Corps already had ecosystem initiatives underway in the urban corridor: the Albuquerque Biological Park Tingley Ponds and Wetlands Restoration Project to rehabilitate Tingley Beach and create a variety of wetland habitats in the bosque, and the Route 66 Project (formerly known as the Bosque Revitalization Project @ Route 66), a feasibility study for ecosystem restoration of the bosque between 1-40 and Bridge Street. In response to concerns raised that the enterprise lacked integration with ongoing bosque projects and that federal funding for the new program might somehow supplant monies allocated to the long-laboring Bosque Initiative, the project manager assured other restorationists that the plans would build on existing work like the Albuquerque Open Space *Bosque Action Plan* and the *Bosque Biological Management Plan*. Since then, the Route 66 and Bosque Ecosystem Restoration projects have broadened involvement and created a cooperative working relationship with other Albuquerque reach initiatives, including those of the City of Albuquerque Open Space Division, New Mexico State Parks, and the Middle Rio Grande Conservancy District.

U.S. Army Corps of Engineers Bosque Ecosystem Restoration

Middle Rio Grande Bosque Ecosystem Restoration Project

The Middle Rio Grande Bosque Ecosystem Restoration Project was initiated in March 2002, in response to authorization from the U.S. House of Representatives Resolution 107-258, calling for an environmental restoration analysis of the bosque from the North Diversion Channel to the South Diversion Channel in the Albuquerque reach of the Rio Grande. The purpose of the reconnaissance study was to look at the costs and advisability of ecosystem restoration, to determine federal interest in funding more specific cost-shared feasibility studies. The reconnaissance was completed in June 2002., and the Middle Rio Grande Conservancy District has been designated the local sponsor for the feasibility study, which will investigate the opportunities for restoration of a more-naturally functioning bosque ecosystem by means such as removal of non-native vegetation and dead and down vegetation debris; the removal of jetty jacks not vital to flood control; the revegetation of native plant species; and the reestablishment of the hydrologic connection between the Rio Grande and the bosque to ensure natural reproduction of native vegetation. Field work for establishing baseline conditions in the study area is currently underway; existing conditions were dramatically altered by the fires in 2003 and 2004. Other vital components of the study are improved public access and the opportunities for educational interpretive sites for increased public awareness.

Community input and involvement are cornerstones of the process. There are over thirty agencies and non-government organizations with a stake in the bosque, and more than twenty neighborhood associations adjacent to the project area from which the Corps has consistently solicited input. Many of these entities have assisted with the development of strategies for determining baseline conditions. Community input from the reconnaissance study has been incorporated into the Corps' planning process. There will be additional community meetings throughout the feasibility study process, which will take three more years to complete.

Route 66 Project

The Route 66 Project (originally known as the Bosque Revitalization @ Route 66 Project) was also launched in 2002, authorized by Section 1135 of the Water Resources Development

Act of 1986. A feasibility study was begun in 2002 to determine the advisability of undertaking environmental restoration measures to improve the Rio Grande bosque from I-40 downstream to the Barrelas Bridge. The Route 66 Project can be thought of as a smaller-scale pilot study for the Middle Rio Grande Bosque Ecosystem Restoration Project. Alternatives developed and implemented in this project area will be analyzed to see if they can be applied throughout the Middle Rio Grande bosque. Again, the Middle Rio Grande Conservancy District is the non-federal sponsor for the project. Opportunities and alternatives for consideration include restoration of the riparian gallery forest; improved habitat to encourage biodiversity; removal of jetty jacks, exotic plants, and debris, and the replanting of native plant species; fuel reduction measures to lessen fire hazard and increase public safety; improved educational and interpretive opportunities; and improved access for passive recreational use of the bosque. The Route 66 Project Feasibility Study is scheduled to become available for public review in the summer of 2005. (Lynette M. Giesen, Water Resources Planner, Albuquerque District, U.S. Army Corps of Engineers, 2005)

Another program was approaching culmination after years of work and several in-house products: the August 2002 *URGWOM News* announced that prospective users of the highly-anticipated Upper Rio Grande Water Operations Model would soon get to run test scenarios with it. The Corps, the Bureau of Reclamation, U.S. Fish & Wildlife Service, USGS, the Bureau of Indian Affairs, the International Boundary and Water Commission, Sandia and Los Alamos National Labs, and others would be asked to use the model and then return it with saved output files to its developers for further refinement.

Upper Rio Grande Water Operations Model

The Bureau of Reclamation, U.S. Army Corps of Engineers, Bureau of Indian Affairs, U.S. Geological Survey, International Boundary and Water Commission (US Section), U.S. Fish & Wildlife Service, and several other entities signed a Memorandum of Understanding (MOU) for the development of an Upper Rio Grande Water Operations Model for Enhanced System Management in 1996. The MOU identifies the needs for a unified water operations model and establishes a broad time frame for model development. A plan for the model was developed with review and input from the signatories and interested stakeholders, and was distributed in February 1997. The scope and intent of the plan is to develop a numerical computer model capable of simulating water storage and delivery operations in the Rio Grande Basin. The primary purpose of the model is to facilitate more efficient and effective management of basin's water supply.

In 1997, a multi-agency modeling team-developed physical and accounting conceptual models for the Rio Chama test reach. The team completed construction and testing of the test reach model using RiverWare in March 1998. Accurate definition of the physical system is ongoing with calibration of the physical model for the main stem. In 1999, the team completed the initial version of the physical model, which can perform multicontractor accounting and forecasting functions required for water operations. Model testing and verification continued in 2000. Model results were compared to existing daily programs for 1995 and 1996. Verification and validation of the accounting, forecasting, and water operations model continued in 2001. Additional calibration through the Middle Rio Grande continued in 2002. Data used in the development of the daily water operations model were described in metadata

files and were made accessible through the URGWOM website. The Operations model will also be extended into Colorado for flood control operation at Platoro Reservoir and below El Paso, Texas. A planning version of the model was completed in 2003 to aid in evaluating alternatives in the Upper Rio Grande Basin Water Operations Review and EIS. Draft documentation of the planning model is on the URGWOM website, (www.spa.usace.army.mil/urgwom) and additional accounts, rules and corrections from testing the planning model have been incorporated into the operations model. In 2004, sensitivity analysis on meeting target flows at Central and San Acacia under low flow conditions and Phase 1 testing of the model by cooperating agencies were completed.

Upper Rio Grande Water Operations Review

The Corps, Reclamation and the state of New Mexico, through the New Mexico Interstate Stream Commission, initiated a joint effort to review reservoir and river operations in the Rio Grande Basin above Fort Quitman, Texas. A Memorandum of Agreement was signed by the joint lead agencies on January 24, 2000. The purpose of the Review is to develop an integrated plan for water operations. The Review focused on existing facilities and changes in operations that can be implemented within existing authorities. It is needed to increase system efficiency and accommodate changing water management requirements through a range of hydrologic conditions. It is also needed for National Environmental Policy Act (NEPA) and Endangered Species Act compliance. The planning version of the Upper Rio Grande Water Operations Model (URGWOM) was be used extensively in developing and evaluating alternative operating plans. The NEPA compliance process provides the vehicle for conducting the review. A notice of intent to prepare an Environmental Impact Statement was published in February 2000. Public scoping meetings, technical team organization and study plans were completed in 2000. In 2001, the teams described current operations and began draft alternatives development. Public meetings on the individual draft alternatives were held in 2002 and the comments were considered in formulation of the draft alternatives. Evaluation of alternatives continued in 2003 with the completion of the planning version of the URGWOM model. Additional products include FLO-2D model, vegetation surveys, aquatic habitat model, and other qualitative and quantitative tools and resource baseline data. A preliminary draft EIS was completed in 2004. The draft EIS is expected to be completed in 2005. The Record of Decision is scheduled for 2006. (Albuquerque District Office, U.S. Army Corps of Engineers, Rio Grande Compact Report, 2004.)

New Mexico State Parks, Albuquerque Open Space Division and Open Space Advisory Board, and the Middle Rio Grande Conservancy District all approved amendments to the Rio Grande Valley State Park Management Plan (City of Albuquerque, 2002). The changes refined the MRGCD's role in park management, and reflected, among other things, an increased emphasis on fire protection, ecological diversity, and environmental education and monitoring. Work was underway in the park to remove jetty jacks from the bosque at both Central Avenue and Bridge Boulevard near the National Hispanic Cultural Center, and to clear non-native understory and trees to reduce fire danger, particularly at Rio Bravo Boulevard. New Mexico State Forestry's Inmate Work Camp had formerly carried out such heavy labor, but now the Albuquerque Open Space Division added staff and machines to do bosque restoration. The program concentrated on burn sites and areas with dangerous fuel loads, and once basic rehabilitation was complete, various citizens groups and community-minded businesses were beginning to assume the follow-up maintenance for specific locations.

Lessons in how to break free of stalemate positions were being learned elsewhere that summer. In politically charged arenas like the ESA Collaborative Program, where defending turf often seemed the primary motivation for attendance, individuals endured numerous lengthy and, at times, frustrating meetings. Yet, several subcommittees had been formed to deal with various components of the ESA program in the Middle Rio Grande, and it was in these more intimate circumstances that consensus was being reached by increments, and species recovery work began to go forward.

A case in point was the Habitat Restoration Subcommittee, which was meeting every other week. The group was in the midst of reviewing a number of "white papers" on relevant subjects including the habitat requirements of the silvery minnow and willow flycatcher, river hydrology and morphology, existing and future conditions, and net Middle Rio Grande depletions. The papers would be included in the Habitat Restoration Plan to be produced by Tetra Tech, EMI. "The intent," according to subcommittee's co-chairs Chris Gorbach of the Bureau of Reclamation and Gina DelloRusso of Bosque del Apache National Wildlife Refuge, was to "have something that could serve more than one project and offer some baselines for decision makers at the Bureau of Reclamation, the New Mexico Interstate Stream Commission, etc." It was important, they believed, to include dissenting views and acknowledge controversial areas, and to decide whether the disagreements were in principle or in particular so that some degree of consensus could be reached on what needed to be done. For example, one over-arching question regarding river restoration in a fully appropriated stream system is whether it will require *more* water. A method was needed for determining basic water budgets for restoration proposals. A simple "farm field" type of approach was proposed, similar to one being used by the Corps of Engineers and the Bureau of Reclamation for the pilot habitat restoration project at the burn site in Los Lunas. Analysis could include total acreage of the proposed project, a survey of existing conditions with a list of vegetative and soil types, and some projection of what the area would look like after restoration, or, what it might look like in the future if no rectification was done. From such simple comparisons one could conceivably calculate whether the project would save water, cost water, or break even. Attendees at the Habitat Restoration Subcommittee meeting in August of 2002 proposed a number of categories the analysis ought to include (*i.e.,* cottonwoods, willow, saltgrass and other grasses, Russian olive, saltcedar, sweet clover and sunflower, open water, sand bars, etc.) and discussed how mixed stands of vegetation might best be reported. They also proposed using both a high and low water use number for each category in order to capture the variability of a particular site. The topic was difficult and even potentially divisive, but the necessary dialogue was occurring, and with input from all sides.

In late summer, Middle Rio Grande regional water planners announced a fifth series of Community Conversations to be held in September. Members of the public were encouraged to select their initial preferences from forty-four management alternatives that had been postulated to balance regional water use with renewable supply. The preferred alternatives would then be used to build 'scenarios' for further public review. Ultimately, one scenario would serve as the basis for the regional water plan, due to be submitted to the New Mexico Interstate Stream Commission in 2003. The alternatives were grouped into seven categories: changes in water usage, the decrease or regulation of water demand, increases in water supply, water quality protection, water rights, funding for water initiatives, and implementation of the water plan. Responses gathered at each of the six Community Conversations and from mail-back cards indicated a lack of comprehension of the crucial connection between watershed health and water supply, and the longing for a silver bullet that could balance the water budget without much personal pain. Residents overwhelmingly preferred options that would reduce evapotranspiration, such as restoring and managing native bosque vegetation and shifting water storage to reservoirs at higher elevations to reduce the hit the Middle Rio Grande takes in evaporation off Elephant Butte. Respondents also wanted to maximize irrigation efficiency, but overwhelmingly they did not support metering surface irrigation flows or groundwater supply wells, including domestic wells. The public also

appeared to like the idea of "growth management plans" which integrated land and water use, but there were objections to every single alternative that provided the authority required to accomplish this, or to fund it.

For most Middle Rio Grande urban dwellers, water shortage was simply not a reality. While New Mexicans in Santa Fe and Las Vegas dutifully watched their evergreens, grassy sports fields and public lawns die for lack of water, Albuquerque installed seventy acres of turf at Balloon Fiesta Park and city administrators reassured constituents that *their* city was drought proof.

By the fifth of September, irrigation on the MRGCD's non-tribal lands had ceased, two months short of a normal season, and the Bureau of Reclamation was nearly out of the water it had procured for the silvery minnow. Environmental plaintiffs in the ongoing federal district case now petitioned for the release of another 20,000 acre-feet of San Juan-Chama water from Heron Reservoir to see the endangered fish through to cooler weather. But the request met an angry wall. As reported in the *Albuquerque Journal* that week, mayor Martin Chavez declared the city would not contribute anything more to sustain the silvery minnow, and referred to the new demand for hydraulic aid as taking "water from the mouths of our children." State Engineer Tom Turney also opposed the release on behalf of the City of Santa Fe, already crippled by drought, and New Mexico Senator Pete Domenici called seizure of water by the courts for the minnow "a frontal assault on the people of New Mexico and their livelihoods." All three wanted a delay of any more releases from Heron because an appeal of Judge James Parker's decision in the minnow case was pending.

> *"The amount of drinking water that actually goes into our mouths is less than one percent of what we use overall. Most people drink between two and three quarts a day. You might drink a gallon a day if you're out there really working. Yet the average Albuquerquean is using nearly 200 gallons a day. One gallon out of two-hundred? Do the math." (Ross Coleman, Hydra Aquatic, Inc., personal communication, 2002.)*

The following week, the U.S. Fish & Wildlife Service issued a draft Biological Opinion that would, with review and modification, result in a 10-year Biological Opinion of Bureau of Reclamation and Corps operation within the Middle Rio Grande (U.S. Fish & Wildlife, 2003). Surprisingly, it argued against an autumn release of San Juan-Chama water from Heron Reservoir: if the drought continued into 2003, there would be little left to sustain the fish (or anything else) through worse times ahead. Instead, the agency recommended holding onto the water until spring; operating Middle Rio Grande Conservancy District works to help provide spawning habitat for the silvery minnow; and coordinating with the Bureau of Reclamation to prevent the eggs from being flushed downstream, trapping any resultant fry below dams along the river. But on September 18, Judge Parker stuck fast to his April ruling and ordered the Bureau of Reclamation to release 40,000 acre-feet of San Juan-Chama contract water to keep the Rio Grande wet over the next forty-five days. Essentially setting the Biological Opinion aside, he prescribed using MRGCD canals to bypass minnow-poor reaches of the river and ensure a minimum flow of fifty cfs at San Acacia.

In response, municipal, MRGCD, and state attorneys vowed to file yet another appeal. But the middle valley's luck held yet again, and on September 20—the autumnal equinox—it began to rain. In a matter of hours, silvery minnows below San Acacia Dam were swimming in a flow of 1,000 cfs.

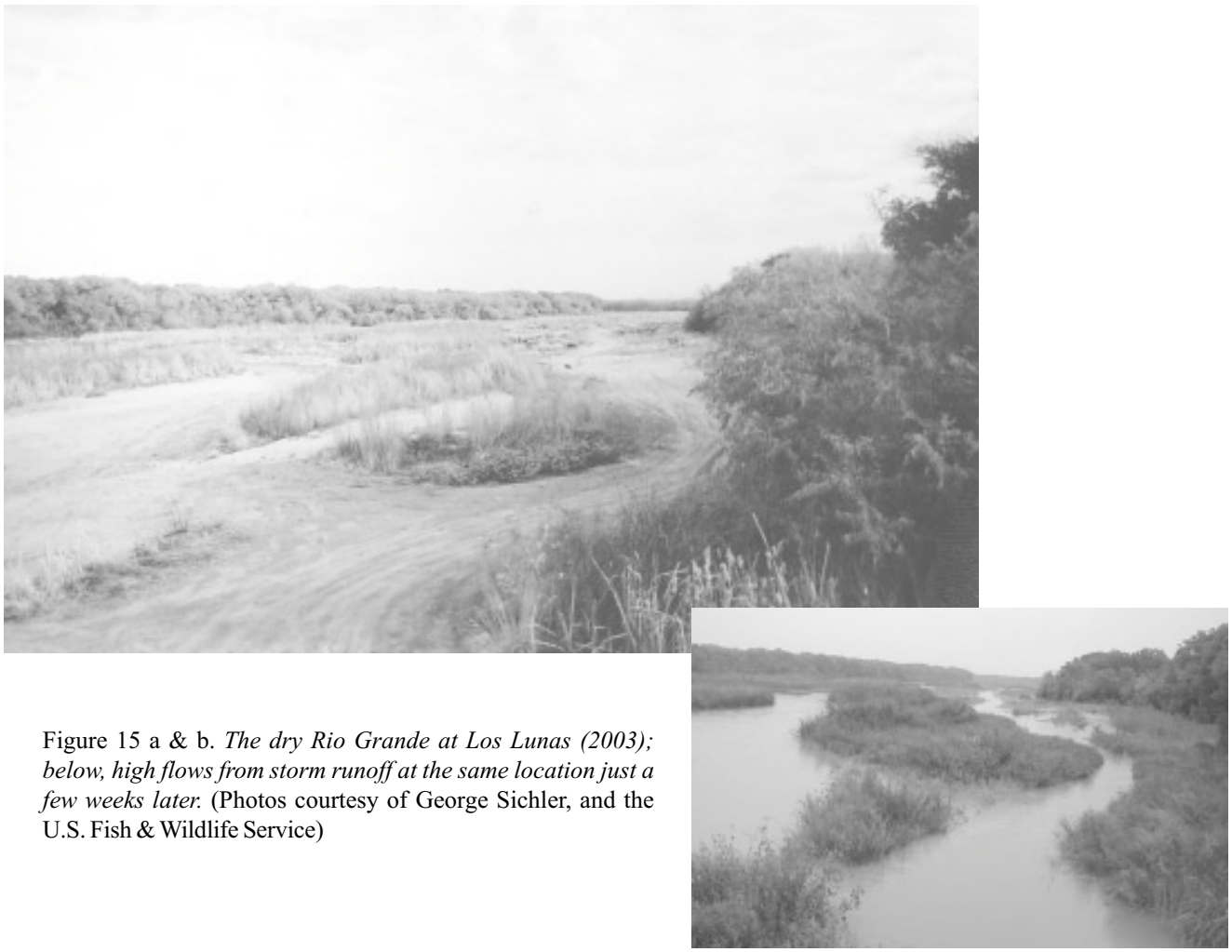


Figure 15 a & b. *The dry Rio Grande at Los Lunas (2003); below, high flows from storm runoff at the same location just a few weeks later.* (Photos courtesy of George Sichler, and the U.S. Fish & Wildlife Service)

Concurrent with the latest species battle, and with more than $1.5 million in project requests, FY2003 funding for the Bosque Initiative/BIG was eliminated from the U.S. Fish and Wildlife Service budget. If demand for the program had grown, the federal allocation most certainly had not.

In preparation for the 2003 session, the Legislative Water and Natural Resources Committee conducted one of its monthly meetings in Socorro at the beginning of October. The agenda included Middle Rio Grande Conservancy District and Elephant Butte Irrigation District concerns; Endangered Species Act administration; regional water planning; domestic wells; water quality; electric power plant water demands; saltcedar control; acequia governance; and federal drought assistance. Water, it seemed, was finally on a front burner with state lawmakers.

On October 18, the 10th Circuit Court of Appeals granted a stay of Judge James Parker's order to release San Juan-Chama water from Heron Reservoir for the silvery minnow once the Rio Grande's flow fell below 50 cfs at San Acacia Diversion Dam.

With the urban irrigation season winding down, Albuquerque city councilors requested an administrative and financial audit of the municipality's water conservation program. There were questions about the figures employed to compare Albuquerque's per capita water use to other southwestern cities, and criticism that the program consisted mainly of voluntary residential compliance with minimal water saving rules. There was also the charge that water conservation funds had been used to run ads denouncing the court ruling on the release of San Juan-Chama water for the silvery minnow. Under mounting pressure from environmentalists, controlled growth advocates, city council members, and even the head of the water conservation department, the mayor announced a spate of "more ambitious water conservation goals" in the waning days of October. The measures included bigger rebates for installing low-flow toilets and replacing lawns with xeriscaping, matching grants to businesses undertaking water conservation improvements, and a multi-stage drought management plan to ration water use according to drought severity.

> *"A lot of folks inside and outside of government are in denial about our water situation…" (Albuquerque City Counsilor Eric Griego, Albuquerque Tribune, October 28, 2002.)*

On November 2, a suit was filed against the U.S. Environmental Protection Agency for approving revisions to New Mexico's water quality standards that continued to exempt irrigation facilities and dams from complying with the Clean Water Act. Forest Guardians and Defenders of Wildlife also charged EPA with failure to complete a consultation with the U.S. Fish & Wildlife Service to determine the effects of the state's water quality standards on threatened and endangered species.

In early December, the Office of the State Engineer convened a hearing on the City of Albuquerque's application to divert an average 94,000 acre-feet a year from the Rio Grande for the municipality's Drinking Water Project. The permit was under protest from a coalition of agricultural and environmental groups that included Amigos Bravos, the Assessment Payers Association of the MRGCD, Rio Grande Restoration, the Sierra Club, the Socorro Soil & Water Conservation District, and individual landowner John Carangelo of Socorro. The city proposed construction of an inflatable diversion dam near the Alameda Bridge in Albuquerque's North Valley, where a combination of municipally owned San Juan-Chama and native Rio Grande water would be removed from the river, purified, and piped to urban homes, businesses, and industries. Roughly half of the water would be returned to the Rio Grande as effluent from the wastewater treatment plant located fourteen miles south of the project diversion point.

Protestants contended the project would have detrimental effects on senior water right holders, on the riparian corridor through Albuquerque, and on the basin's already-mined aquifers. They argued that the city's San Juan-Chama water had in fact been supplementing the Rio Grande for several decades through leases, gifts to multiple users, and releases to offset the effects of groundwater pumping on the river. In addition, 57,500 acre-feet of mined groundwater (half the amount Albuquerque pumped from the aquifer each year,) had long been added to the river as return flow via the wastewater treatment plant. With the advent of the Drinking Water Project, however, both of these man-made 'tributaries' would be reduced or eliminated entirely, and the river would be divested of at least 79,500 acre-feet annually. Coalition protestants further held that connections between surface flow, shallow groundwater, and the deep aquifer are extremely variable in the Albuquerque basin, and that before a permit could be granted to deplete the river, more investigation was needed relative to the degree and destination of seepage from both the river and the MRGCD conveyance system, the rate of aquifer recharge, the efficacy of the city's offset requirements, and possible impacts to pre-basin and domestic wells drawing from the shallow aquifer in the area.

By December 13, both city and coalition arguments had been heard, and a continuation of the proceedings had been set for February of 2003. The state's case would have to wait, and in the interim, much would change, including New Mexico's Governor, and the State Engineer who would eventually be called upon to make a decision on the permit.

Just before Christmas, the Interstate Stream Commission released a report by S.S. Papadopulos & Associates (SSP&A, 2002) on water efficiency in the MRGCD. The study had been underway since 2000 to identify ways to improve the irrigation delivery system, and to evaluate the agency's progress on its metering network. In a cover letter to the report, Interstate Stream Commission engineer Norm Gaume said, "It is clear that the MRGCD can be more efficient. The drought year of 2002, one of the worst hydrologic droughts on record in the Middle Rio Grande, and the operation of the MRGCD in response to that drought, provide clear evidence that greater efficiencies are achievable and sustainable. A key...was the unprecedented cooperation...between the MRGCD, the Interstate Stream Commission, the Bureau of Reclamation, the U.S. Army Corps of Engineers, the U.S. Fish & Wildlife Service, the City of Albuquerque, and the Six Middle Rio Grande Pueblos. Given the trends of lower water supply and increased water demand...continued effective cooperation is essential."

The report proposed steps to be taken by the MRGCD to improve water management. Short-term operational refinements included training district ditch riders in the principles of irrigation scheduling and rotation; developing rotation methodologies that would be consistent throughout the district and its several divisions; improving coordination with the Pueblos relative to scheduling and rotation; and implementing selected infrastructure improvements. The report also recommended establishing the amount of irrigated acreage in the district and the water rights needed to serve that acreage as a stride toward determining the legal limits of the MRGCD's diversion. Such an assessment could not be accomplished, however, without specific knowledge of where the water was currently going, and that required a completed metering program. In lieu of the necessary numbers, it was still presumed that an inefficient delivery system and untutored irrigators were wasting a lot of water.

In the closing days of Governor Gary Johnson's administration, the Blue Ribbon Task Force he had named to study water issues some seven years earlier made recommendations for "ensuring a sustainable water supply for New Mexico." The group called for a more modern approach to resource management and administration, urging adoption of a state water plan, and a clearinghouse for water information. The state was urged to allocate money for water litigation, adjudications, collaborative programs, and the Water Trust and Water Project Funds. Other recommendations included an accurate inventory of domestic wells statewide, some means of constraining the development of new wells in critical management areas, and possibly, the required metering of domestic wells. The Task Force also proposed an expanded water conservation program, though what was apparently meant by 'conservation' was a more facile means—via banks and markets—of moving water from those who had it to those who wanted it. Finally, the state was pressed to pursue aggressive watershed management to "improve forest health, prevent catastrophic fires, increase water yield, improve water quality, improve local socioeconomic conditions, and provide for cultural well-being of local communities."

2003

Before the year had even begun, administrative change was underway up and down the ladder of state government. Former New Mexico congressman, Secretary of the U.S. Department of Energy, and Ambassador to the United Nations, Bill Richardson, had been elected Governor. There would be an all-new cabinet; new Interstate Stream Commissioners, including the first tribal appointee in the agency's history; a new Interstate Stream Commission engineer with a background in acequias and mutual domestics; and a new State Engineer, former head of the Office of the State Engineer Water Rights Division and more recently in charge of the New Mexico Environment Department. Prior to these selections, Richardson had asked outgoing water chief Tom Turney not to rule on the pending application by the City of Albuquerque regarding its Drinking Water Project. A spokesman for the Governor-Elect said the new administration did not want to be bound by decisions made in the final days of its predecessor.

On January 3, City of Albuquerque officials held a ground-breaking ceremony along the Rio Grande at Alameda for a $22 million project to divert 3,000 acre feet of San Juan-Chama water to irrigate the grounds at Balloon Fiesta Park, various sports fields, and acres of lawn at Journal Center. The "nonpotable diversion plan" would be the first component of the municipality's overall strategy to reduce its reliance on groundwater. Submitted to the Office of the State Engineer and approved via a separate permit application from the disputed Drinking Water Project, the nonpotable diversion would for all intents and purposes enable the city to begin construction on the larger DWP before the State Engineer hearing on it had been completed.

Middle Rio Grande Water Assembly constituency groups were formulating vision statements to be aired at an annual meeting later in the spring. The document submitted by the Assembly's environmental delegates was admirably ecumenical and direct:

> In the debate over our region's limited water supplies, environmental advocates are often accused of putting fish before people. On the contrary, it is in large measure our concern for our own species that compels us to advocate for the protection of the river. Humans are part of life's intricate and interconnected web, and severing any single strand of that web risks unraveling the whole. We act because our own well-being depends on preserving the web of life. A clean and healthy Rio Grande is essential to the agricultural traditions of the middle valley, as well as to our urban population that will increasingly depend on surface water for domestic uses. The Environmental Advocates' vision is of a region centered on a vibrant, healthy Rio Grande ecosystem and watershed. The river should dry only in the most severe droughts. It should flood between levees in the springtime most years and otherwise mimic the natural hydrograph and the natural connection between floodplain and river. The myriad of artificial constraints that divide, channel, and otherwise modify the flow of the river—dams, levees, jetty jacks, drainage canals, artificial conveyance channels, and so forth—should be eliminated or their adverse environmental effects mitigated to the extent that it is reasonably possible to do so. The Bosque Biological Management Plan provides the blueprint for what needs to be done to restore the river. In order to achieve this vision, it is essential to recognize that in this desert region, we cannot continue to indefinitely expand human use of water and that we have, in fact, already reached and even exceeded the limit of water that can be devoted to human uses. The essential element of the Environmental Advocates' balancing of the region's water budget is that no water beyond present use should be allocated to municipal, commercial, and industrial

> uses. A second essential element of the Environmental Advocates' vision is that all must use our water resources in the most efficient manner possible, and in ways that are consistent with the fact that we live in a desert. (Richard Barish, e-mail to the Water Assembly list serve, January 14, 2003.)

At the same time, Water Assembly members were sparring over the hydrologic computer model of the basin being created by Sandia National Labs. The cooperative modeling effort had all but come to a standstill about which variables to include. Some wanted evaporation from Elephant Butte Reservoir removed from the region's water budget; others hoped to dismiss the past effects of groundwater pumping, or disputed the overall amount of riparian acreage to be included. Non-agricultural interests were particularly intent on finding 'new water' through the reduction of MRGCD diversions. They were advised that Middle Rio Grande hydrology was a good deal more complex.

> *"MRGCD water consumption over the entire district is probably within the range of 120,000 to 200,000 acre feet per year. Reductions in diversions into the MRGCD system will result in a redistribution of water within the valley, river, and upstream storage reservoirs, but will not necessarily have a large impact on water consumption within the district. There are many viable arguments supporting the need for MRGCD to reduce river diversions; however, freeing water for other consumptive uses is not among them, as little 'new water' would be generated by reduction of diversions." (Karen Lewis, S.S. Papadopulos & Associates, e-mail to the Water Assembly list serve, February 7, 2003.)*

> *"...[the Sandia model] fails to reflect any quantification of the groundwater accessible to city wells. It lacks any quantifiable projection of consumptive depletion (withdrawals) of the aquifer. How can one assess withdrawals from a nonrenewable resource without having a projected EMPTY indicator? Try driving a car without a fuel gauge—like this city is mining water—and see if you don't end up stuck in the desert with no way home." (Martin Zehr, e-mail to the Water Assembly list serve, August 22, 2003.)*

A level up, the Governor was promising a *state* water plan that would integrate completed regional water plans, an inventory of state water resources, and a drought management strategy by the beginning of 2004.

In February, Albuquerque's mayor proposed a several-stage drought management strategy for the coming outdoor watering season. At the Drought Advisory level, voluntary conservation would be "triggered by 10,000 acre-feet of excess pumping from the aquifer," and outdoor watering would be restricted to three days a week. With a 20,000 acre-foot increase in pumping, a Drought Watch would be activated, and water waste fees would double, fountains and ponds would not be allowed to refill, curbside car washing would be banned, and the surcharges for excess water use would double. With a 30,000 acre-foot increase in pumping, the Drought Warning level would triple surcharges for excess use, restrict lawn watering to two days a week, disallow the planting of new turf or landscape, and require swimming pools to be covered. At the final stage, called Drought Emergency, lawns could only be watered one day a week, and water surcharges would quadruple. To forestall having to implement the more restrictive levels of the strategy, the administration proposed increasing the rebate for low-use plumbing fixtures and for both residential and business landscape conversion to xeriscape.

"Conservation should be the norm in this desert city, because the water we so easily consume today is actually borrowed from future generations…" (Albuquerque Tribune editorial, February 14, 2003.)

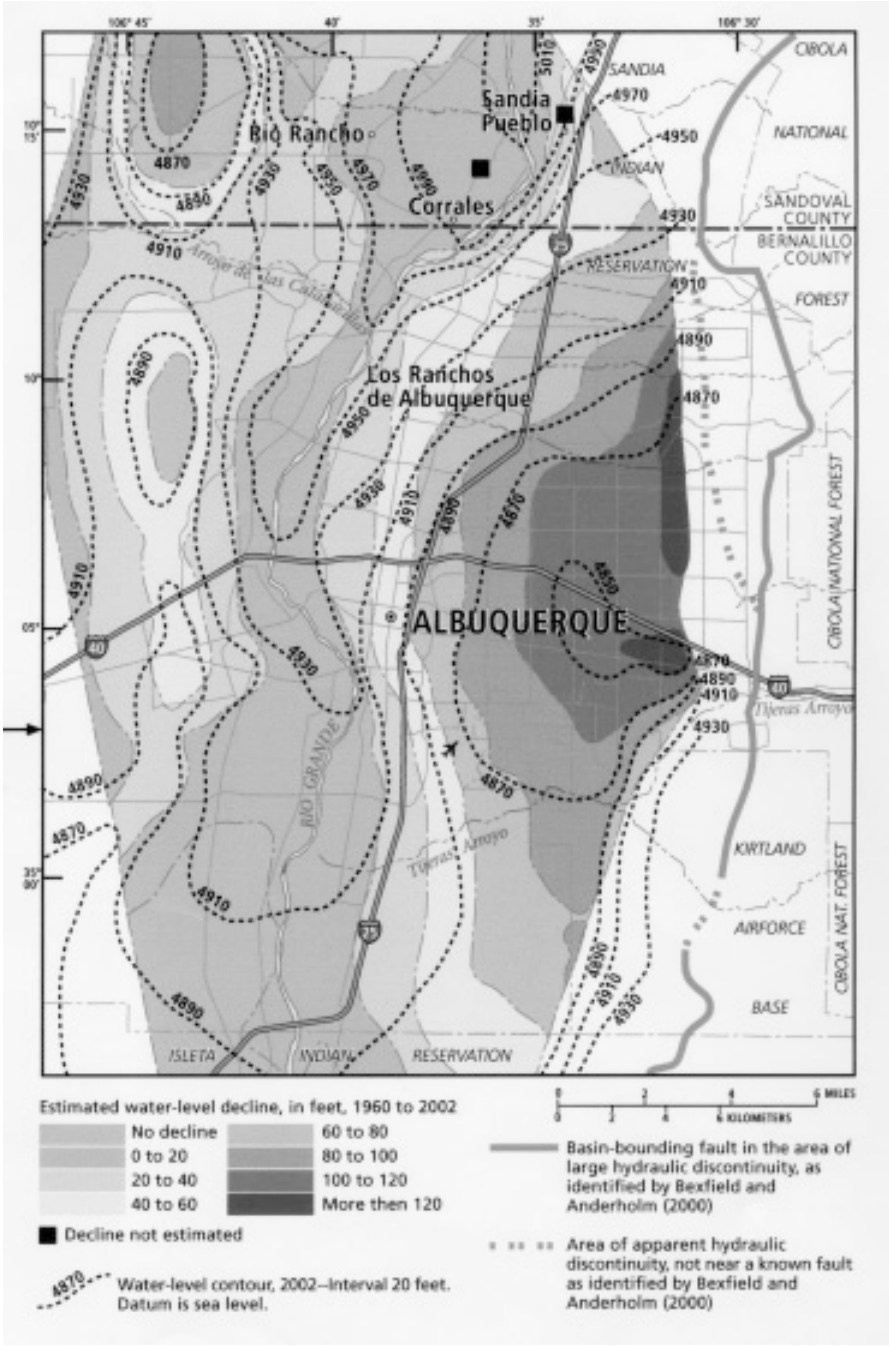


Figure 16. *Groundwater declines in the Albuquerque Basin.* (Brigette Felix-Kludt after Bexfield and Anderholm, 2002)

The U.S. Geological Survey finished a six-year evaluation of groundwater resources in the Middle Rio Grande Basin, showing the aquifer to be even less productive than the 1993 study had indicated. *Ground-Water Resources of the Middle Rio Grande Basin, New Mexico* (Bartolino and Cole, 2002) offered key points about the combined groundwater and surface water system. Groundwater levels have declined with the economic development of the basin. A comparison of historic and current water-level maps shows a 160-foot decline in some places, where the aquifer is being pumped faster than recharge is occurring. Past water management policy was based on the assumption that surface and groundwater systems were well connected, but in fact, the high-quality portion of the aquifer is far more limited than once thought. Numerous faults, as well as aquifer materials of "substantially different hydraulic properties" interrupt the movement of groundwater. Finally, there is less mountain front recharge than previously believed, and the current riparian forest consumes a significant amount of surface flow and groundwater.

> *"The direction and amount of water flowing between the Rio Grande and the Santa Fe group aquifer system is one of the most important hydrologic issues in the Middle Rio Grande basin. Not only do the volume and direction of flow between surface and ground-water affect the amount of water in the river, they affect the volume of ground water available in the aquifer. In the Albuquerque area, ground-water pumping has lowered ground-water levels so that the river loses more flow to ground water than it did during predevelopment conditions…" (Ground-water Resources of the Middle Rio Grande Basin, New Mexico, Bartolino and Cole, 2002, p. 76.)*

On March 17, the U.S. Fish & Wildlife Service released the final Biological Opinion on Bureau of Reclamation and Corps water operations within the Middle Rio Grande (U.S. Fish & Wildlife Service, 2003). In light of the continued drought, the plan required a flow of 300 cfs through the Albuquerque reach from May 1 to June 15 to accommodate the silvery minnow's spawning season. After that, the flow would be allowed to drop to 100 cfs in recognition of the fact that some reaches of the river—including minnow habitat—might go dry. Instead, the agency proposed to rely on rescue and transplant efforts to sustain the species, with increased emphasis on improving water quality in the river, providing a fish passage at San Acacia Diversion Dam, restoring habitat from Velarde to Elephant Butte, constructing additional silvery minnow breeding and rearing facilities, and reintroducing minnows to the river above and below the Middle Rio Grande.

That same day, a final rule went into effect designating 157 miles of the Rio Grande below Cochiti Lake as critical habitat for the minnow (Federal Register, 2003). The designation included the Jemez River from Jemez Canyon Dam to the Rio Grande confluence, but excluded the lands of Santo Domingo, Santa Ana, Sandia and Isleta Pueblos.

The Office of the State Engineer hearing on the City of Albuquerque's application to divert water from the Rio Grande for its Drinking Water Project resumed on February 24, this time in Albuquerque. Office of the State Engineer Water Right Division witnesses testified on the feasibility of the city's plan for monitoring river flow, its water conservation program, and its proposed accounting for seepage and evaporation. During cross-examination, OSE staff agreed the plan might not be conservative enough to protect either the river or other water right holders. Witnesses acknowledged that return flow ought to be monitored at least monthly, if not daily; that the municipality's water conservation goals could be revised downward by twenty to fifty gallons per person per day; and that conveyance losses should be estimated on the high side to protect the river until more precise information could be obtained. Several disconcerting things came to light during the state's case, foremost among them the fact that the Water Rights Division had not considered possible impacts of the new diversion on groundwater in the Albuquerque reach because the application in question involved *surface* water.

In spite of the State Engineer's avowed interest in conjunctive management, the Water Rights Division had not evaluated the effects of historic and proposed pumping on flows through the Albuquerque reach in relation to the new surface application, nor was any evaluation done on possible impacts to wells in the shallow aquifer between the proposed diversion and return flow points. One state witness admitted the department has no real idea how many individual wells there might be, and that essentially, the OSE depends on Middle Rio Grande Conservancy District canals and drains to keep the water table stabilized. Another problematic disclosure was that the state had not been apprised of the settlement agreements between the city and twelve other protestants in the case, although it was recognized that conditions contained therein might affect the state's ability to administer water.

> *"Any appropriation of water has impacts. Some might be negative. Whether they rise to the level of 'impairment' is another thing." (Former State Engineer Eluid Martinez, in testimony as an expert witness for the City of Albuquerque, February 27, 2003.)*

In March, the U.S. Army Corps of Engineers Bosque Revitalization Project hosted three more meetings to acquaint the public with "concepts for restoring the Albuquerque bosque into an ecologically sustainable natural environment." Plan participants were the Corps, the City of Albuquerque, and the Middle Rio Grande Conservancy District. Clearing undergrowth and exotics from the river corridor through Albuquerque was already underway. A five-year program to remove exotics from the reach containing Rio Grande Valley State Park had already begun, and Albuquerque's mayor voiced hope of cleaning up some five-hundred acres a year.

With water storage in the Rio Grande Basin at thirty-seven percent of average, and Article Seven of the Rio Grande Compact activated to assure the passage of native flows, the Middle Rio Grande Conservancy District was counting on its annual allotment of San Juan-Chama water to get through the irrigation season. Instead, the agency was put on notice by the Bureau of Reclamation's Albuquerque Office that its diversions might be curtailed as early as April 15 if more water was needed for the silvery minnow. A district court hearing over title to the MRGCD's works was still several months off, and with Reclamation acting to reduce diversions to middle valley farmers, the potential for a local version of the Pacific Northwest's Klamath Basin conflict seemed very possible. To stave off such a debacle, the MRGCD appealed to New Mexico Senator Pete Domenici, who promised help in finding a solution that would accommodate all the parties.

On March 24, Rio Grande Restoration gathered regional leaders of the environmental community together to learn more about the whole-system approach to recovery favored by the region's academic experts in riparian ecology. Attendees heard from the river's longtime evangelist, Cliff Crawford, lead author of the *Bosque Biological Management Plan*, who said, "For millennia, and especially since the end of the last Ice Age, the Rio Grande has been fairly shallow and braided. It avulsed, it wandered all over its floodplain, and it left behind bosque that it had created. Everything was changing all the time. 'Mixed setting' was the average state of the bosque and today's endangered species did survive this long period of change." Next, the group received a presentation on Florida's Kissimmee River restoration program, [see page 113] from University of New Mexico biologist Cliff Dahm, a member of the Kissimmee's scientific peer review team. The $600 million Kissimmee project focuses on restoring *ecosystem integrity*, which includes biological health and diversity, but also good hydraulic conditions comparable to other healthy rivers. "In the Middle Rio Grande," Dahm noted, "[restoration] is being driven by two species. Other things that might be more system-friendly don't get funded." Environmental groups also heard from the former head of the Albuquerque District Corps of Engineers, Ret. Col. Steve Wagner, who noted that the Corps is "reestablishing itself in the restoration business," and that much potential exists for "bringing necessary funds to New Mexico."

By the third of April, according to information posted on the Middle Rio Grande Water Assembly list serve, the Governor had signed into law the following water-related initiatives passed by the 2003 Legislature:

- A measure to allow residential use of graywater for landscape

- An amendment to the Water Project Finance Act to create a drought strike team, and to set water efficiency criterion for entities seeking funding

- A bill authorizing development of and requirements for a State Water Plan

- Bills giving acequias the authority to bank water, and to set requirements for changes in point of diversion, place, or purpose of use of an acequia water right

- A measure allowing creation of a special water users' association to lease water from Elephant Butte Irrigation District, inside or outside of district boundaries, with alterations to the procedure for changing the place and purpose of leased water, and limits to the protest and appeal process

- A measure dedicating ten percent of the state's severance tax bonding capacity to water projects

- Development of a comprehensive watershed restoration strategy focused on removing non-native phreatophytes

- A bill to grant the State Engineer authority to adopt rules for priority administration to expedite water marketing and leasing

- A measure to require municipalities, counties and other entities providing more than 500 acre-feet of water a year to develop water conservation plans

- An amendment to the Ground Water Storage and Recovery Act to add the Interstate Stream Commission to a list of governmental entities authorized to store and retrieve such water

- A bill authorizing the State Engineer to study and install devices to accurately measure river flows in real time

Congressional attention, in the form of budget requests, was also on New Mexico's water:

- The Bureau of Reclamation was asking for $10 million to continue river habitat modifications, water leasing and purchases, minnow population management and breeding, refugia construction, fish/stream monitoring, and nonnative tree removal; and another $10 million to begin repair and needed maintenance at twenty-five levee points in the Middle Rio Grande.

- The Army Corps of Engineers wanted $400,000 for the completion of the Middle Rio Grande Bosque study; $800,000 for the Middle Rio Grande flood control project, Bernalillo to Belen; $800,000 for the Rio Grande Floodway from San Acacia to Bosque del Apache; and, $300,000 for the Rio Grande Basin. Another $6 million in Water Resources Development Act funds would go to the Corps to support water infrastructure projects in Bernalillo, Sandoval and Valencia counties. These would

require a twenty-five percent non-federal match, and had been used in the past to improve water and wastewater infrastructure projects in Albuquerque's North and South Valley, and wastewater work in Belen.

- There was $400,000 in the budget to continue federal support for the Albuquerque Water Reuse Project, a cooperative program to reclaim and reuse industrial and municipal wastewater, and to reclaim the city's naturally impaired groundwater.

- Another $4 million was being sought to support scientific research on new arsenic removal technologies for New Mexico communities facing the prospect of increased federal arsenic standards of ten parts per billion. (Sandia National Labs was working on "Specific Anion Nanoengineered Sorbents" to attract and sift out arsenic compounds in drinking water.)

- And finally, there was a proposal to launch demonstration programs on the Rio Grande and the Pecos to determine the most effective means of controlling saltcedar. The FY2003 omnibus appropriations bill included $500,000 in Bureau of Reclamation funding for ongoing saltcedar eradication work on the Pecos River. (Summary of state and federal water legislation provided to the Middle Rio Grande Water Assembly list serve by Elaine Hebard, April 3, 2003.)

Albuquerque city councilors were debating the proposed resolution to create a municipal water budget and a Water Conservation Task Force to help balance it. At the same time, the administration was stinging from another bit of legislation just turned into law: now there were soon to be three Bernalillo County commissioners on the newly created Albuquerque-Bernalillo Water Utility Authority, and the county suddenly had control over development in a five-mile-wide border area where the city had previously enjoyed extraterritorial zoning authority.

The 2003 fire season commenced on April 5 with a 2000-acre blaze in the Rio Grande bosque near Bernardo. The area was, for the most part, comprised of dense saltcedar, but also among the fire's casualties was a University of New Mexico data collection site in the cottonwood canopy north of US-60. Groundwater wells and litterfall tubs were reinstalled immediately, and researchers asked to be allowed to continue monitoring the site in the absence of mechanical restoration activity in order to learn more about natural vegetative recovery and recruitment processes. Seldom is there existing baseline data for an area razed by a non-prescribed burn, and here was a chance to observe the natural succession of recovery*, i.e.* which native vegetative species reappear, and which take advantage of the disturbance.

With water in northern New Mexico reservoirs all but nonexistent in the wake of drought and mandated river flows, federal, state, and MRGCD managers conceived a deal to trade accumulated Rio Grande Compact water delivery credits at Elephant Butte Reservoir for the right to store more water upstream. Elephant Butte's level had fallen below 400,000 acre-feet, prohibiting additional storage at younger reservoirs like El Vado. That meant any gains from snowmelt or spring storms would have to be passed through the system to the Butte, where thousands of acre-feet of water would evaporate to neither state's benefit. Trading credits for storage meant releasing extra water from the Butte to southern New Mexico and Texas irrigators in exchange for the right to hold whatever runoff there might be at higher elevations. The agreement allowed Texas to take delivery of 122,500 acre-feet of credit water from Elephant Butte, and New Mexico to store that same amount upstream—if, of course, it could be wrung from the parched high country. New Mexico would lease 30,000 acre-feet to the Bureau of Reclamation to sustain the endangered silvery minnow; the Middle Rio Grande Conservancy District could store up to 46,667 acre-feet in El Vado Reservoir for the 2003 irrigation season; and 2,500 acre-feet would be reserved for use by the City of Santa Fe. But the arrangement didn't gratify everyone. With Elephant Butte already at a thirty-year low, residents of Sierra

County, who depend on tourism and recreation associated with the state's largest "lake," believed the exchange would negatively impact the county economy. Though the local boating industry owes its existence to the Rio Grande Compact, recreation was not among the reservoir's charter benefits, and eventually, in spite of a protest parade of boats on trailers that snarled Santa Fe traffic, the innovative water deal was approved.

> *"People said this was a 'back room deal,' but there isn't enough space at the State Engineer Office to* have *a back room." (John D'Antonio, to attendees at the Bureau of Reclamation's" 2025" Conference, August 12, 2003.)*

"Heating Up: Coming to Terms with Climate Change in the Southwest," was the topic at the Center for the Southwest's annual conference in Albuquerque. The program, a "discussion about the science and social implications of climate change," was strongly evocative of an earlier symposium, held in Albuquerque in the summer of 1990. After thirteen years, it appeared there were yet a few who harbored doubts about the certainty of global warming.

The April 28 edition of *High Country News*, a publication of regional interest that frequently focuses on Western water, carried a front-page article by Socorro writer Paul Krza entitled, "Indian Power: New Mexico tribes catapult into politics and join the state's water tug-of-war." A new era of interaction between state and tribal governments is underway, the article said, due to positive changes in tribal economies brought about by gaming revenues, and by the appointment of a number of Native Americans to high-level state jobs, boards, and commissions. Governor Richardson's desire to determine the extent of Indian water rights "by collaboration and negotiation rather than by litigation" had special significance in the Middle Rio Grande, where the water rights of Cochiti, Santa Domingo, San Felipe, Santa Ana, Sandia, and Isleta Pueblos remained unquantified.

Leery of an increasing "smart growth" movement in Albuquerque that continued to raise issues such as impact fees and water availability, the owners of the 6,500-acre planned west side community of Quail Ranch petitioned for annexation to the municipality of Rio Rancho. The development, future home of some 50,000 people, was part of a 12,000-acre annexation that would add eighteen square miles to one of the largest cities in the state.

Particularly apropos of the date ('Mayday'), Department of the Interior Secretary Gale Norton listed the metropolitan Middle Rio Grande as one of several trouble spots in the West where a water crisis is "highly likely" to occur by the year 2025. To stave off such conflicts, Interior proposed a new initiative called Water 2025 to focus funding and technical expertise in areas where population growth and environmental needs were straining natural resources. The program would earmark an initial $11 million for modernizing existing water storage and delivery systems, and for exploring new technologies for water conservation and desalination. The money would be appropriated to the Bureau of Reclamation to work in "at-risk" watersheds, with the goals of 1) enhancing water management and conservation through the use of improved technology, better measurement systems, water banking, etc.; 2) improving science and technology to reduce the cost of desalination and waste disposal; 3) assisting communities in development of basin-wide plans to manage water in times of crisis; and, 4) strengthening and improving operations in regard to the Endangered Species Act.

Of course, federal agencies such as the Bureau of Reclamation and the U.S. Fish & Wildlife Service were already involved in resource redistribution. As reported in the *Albuquerque Journal* on May 9, a study by a New Mexico State University agricultural economist found that increased river flows for the silvery minnow had resulted in economic gains for water users in southern New Mexico and El Paso, while in the Middle Rio Grande, minnow releases were commensurate with economic loss.

"Water 2025 is a commitment by Interior to work with states, tribes, local governments and the public to address water supply challenges in the West. These decisions cannot and should not be driven from a federal level. They should be based on—and will require—local and regional support." (Gale Norton, Secretary of the Interior, U.S. Water News, June, 2003.)

"People here who have long wrestled the water monster in the Rio Grande Basin will likely find the [2025] report dated. They know the future is now and the trick will be to keep the conflict from escalating into a war...The one certainty, despite the pro-growth hype of public officials and self-promoting developers, is the amount of water is not expanding, while the demand for it—from cities, irrigators and nature—most certainly is." (Albuquerque Tribune editorial, "A Water Solution Needed Now Or We're All Losers," May 14, 2003.)

An internal audit of the City of Albuquerque's water conservation program initiated earlier by city councilors disclosed that mixed accounting methods were being used to report the program's progress, and that little had been done to reduce water leaks in the distribution system, or to curb excessive use and/or water waste by imposing higher fees and financial penalties. Council members were still at odds with the administration over what interest groups to include on the new conservation strategy task force, approval of a proposed points system for rating the impact of new development on water conservation, and whether a percentage of saved water might be earmarked to protect riverine and aquatic environments.

In mid-May, water resource managers at the 2003 Southwest Drought Summit in Flagstaff, Arizona were urged to plan for years—possibly decades—of drought, and to resist making assumptions about the severity, frequency, or duration of such dry cycles. Meanwhile, in the upper basin of the Rio Grande, a significant portion of the below-average snowpack was evaporating before it could translate into spring runoff.

During June, the Sunday *Albuquerque Journal* ran a series of articles on the looming water crisis in the west. "Dry Horizon: Water In the West" began with a piece called "Change Is Coming," which contemplated the seventy-eight percent boom in New Mexico's population between 1970 and 2000, and the extenuating circumstances that had cloaked an attendant water crisis for nearly three decades. Next, reporters explored the transfer of water from agriculture to municipal and industrial uses. In "From Fields to Homes," which ran on June 8, New Mexico State Engineer John D'Antonio expressed the belief that "a ten percent reduction in agricultural water use could allow the state's population to double." The series continued with "Seeking New Supplies" on June 15; "Drought Is Inevitable" on June 22; and "The West's Future" on June 29.

"...the particular physical attributes of water make it problematic to own. Water is a "flow" resource that is able only partially to be "captured." It is fugitive, it is vital for the sustenance of life, and it is used by multiple parties (plants, animals and people) at successive stages of a natural cycle. Indeed, its value is in these uses as it flows through the users. We try to dam it, but it evaporates and occasionally breaks dams. We put it in pipes, but they leak. We make it dirty or poison it and then pay to clean it up. Sometimes we even try to conserve it and use it productively. But the physical substance H_2O cannot really be "owned" any more than can the air." (John R. Brown, e-mail to the Middle Rio Grande Water Assembly list serve, May 19, 2003.)

Having completed a seventh round of Community Conversations during which stakeholders from various constituency groups constructed scenarios for balancing water use with renewable supply, the Middle Rio Grande Water Assembly now convened a Regional Forum on June 7. The ongoing series of Conversations had helped to elicit regional visions and values. It had also educated constituents about the region's water budget; distilled from public comment a mission for the plan, and a set of goals and objectives; given people a chance to explore with the Sandia computer model a number of options for balancing the water budget; and allowed stakeholders to select which of a long list of alternative actions should receive in-depth analysis. Now participants were asked to critique a composite draft scenario to be included in the water plan. Most refused to endorse the proposal, however, because it could not provide sufficient flow in the river to meet Rio Grande Compact obligations. Approval of regional water plans rests with the Interstate Stream Commission, an agency whose top priority is compact compliance; any water management scenario that failed the compact litmus test was sure to be, as one resolute Water Assembly participant put it, "a non-starter."

On June 12, the 10th Circuit Court of Appeals confirmed Judge James Parker's 2002 ruling that despite non-federal ownership of the water, the U.S. Bureau of Reclamation does have the discretion to curtail deliveries to its San Juan-Chama contractors in order to comply with the Endangered Species Act. The Appeals Court further agreed that the Bureau of Reclamation might also reduce Middle Rio Grande Conservancy District diversions to supply water to the silvery minnow. State officials, the City of Albuquerque, and the MRGCD all voiced outrage at what could be construed as a federal 'taking' of state and private water rights, and both the Governor and Albuquerque's mayor made emergency trips to Washington to meet with New Mexico's congressional delegation. Senator Pete Domenici counseled composure, saying he was working on "legislative solutions" to the minnow problem and that meanwhile, Middle Rio Grande ESA Collaborative Program funds could be used to lease or purchase water for the fish, as well as to restore habitat and build refugia for remaining populations.

> *"[The Endangered Species Act] must be more flexible and reasonable. It's got to deal with broad ecosystems, not very specific issues relating to one species. Not overturned, not terminated, but adjusted to reality and modernized, adjusted not to pit people against fish." (Governor Bill Richardson, Albuquerque Journal, June 14, 2003.)*

> *"The Rio Grande is indeed a broad ecosystem with biotic and abiotic components consisting of, but not limited to, water, sediment, a channel, flood plain, riparian strip, a groundwater interface, insects, fish, and birds stretching from Colorado to the Gulf of Mexico. In order to maintain these functioning components through biological, hydraulic and hydrological processes, the Rio Grande needs a certain amount of water, just as a pump needs a prime…" (Larry Smolka, Letters to the Editor, Albuquerque Journal, June 18, 2003.)*

Riverways

Think of the Rio Grande as a water user, the original water user, the most prior appropriator of water. The work the river does with water is at least as useful to the life of the valley as much vaunted 'beneficial uses' like growing sprawling cities, or food for cattle. The river uses its water in subtle, complex ways, supporting all of life—sorting gravels for trout from sands for minnows, providing magic in the form of underground water, maintaining the great fluttering cottonwoods and their sympathetic migrant birds. The river is a superb engineer,

carving and maintaining a channel to carry away floods while grading off annual increments of silt, sand and stone. Left to its own devices, the river would store some water all over the valley and let this water out again, periodically spreading minerals and nutrients it had collected to revive the valley's fertility.

The river has always done these things and, in contrast to people, when the river has done its work it generously sends the water down the line to bless the next set of users. We late arriving Euro Americans have decided that the water is ours and in our arrogance, that we must improve on the river's ways. Imagine: 300,000 jetty jacks to fool the river into a straighter, narrower and deeper course! Trapezoidal concrete ditches to hurry the water away! What are we thinking? One single-purpose-engineering project has led to another and then another, and nothing one could properly call "improvement" is yet in sight. Straining against reason, we have convinced ourselves that we are masters of the valley and that no self restraint at all is required of us, no honoring of the vital power beyond our mortal selves. Eventually, the dry truth begins to intrude on our delusions: there are limits to the river's generosity. It now seems possible that the great creator of this valley might be made to fail, by us. Is it not therefore wrong, shortsighted and wrong, to drain this river of its water and its energy, to compromise its integrity and diminish its critical capacity to do what rivers do? How shall we who are alive today respond to the fix in which we find ourselves? Will we bear the consequences of refusing to safeguard the blessings given us by the river? Or will that sad discovery be left to posterity?

Consider this: we may not always be able to engineer or litigate our way out of the future our recent actions seem to prophesy. Observing the wondrous ways in which the river patiently breaks down all resistance and builds up life itself ought to give us new ideas. Shouldn't we now accept the work of returning ourselves to harmony with the master of the landscape we inhabit?" (Steve Harris, Executive Director, Rio Grande Restoration, in a speech to "Rio Grande: A Culture of Water" Conference, Santa Fe, New Mexico, June 2002.)

Figure 17. *The Rio Grande at Albuquerque.* (Photo courtesy of Joel Lusk)

During the late spring and early summer, the Socorro Save Our Bosque Task Force conducted a series of workshops as part of its *Conceptual Restoration Plan for the Rio Grande from San Acacia to San Marcial*. The workshops—one on a planning matrix developed for the project, one on geomorphology, and one on biology—examined various "decision-making tools valuable to other river and riparian restoration plans in the Middle Rio Grande valley." A planning matrix was developed to rank and prioritize reach characteristics in the study area, riparian habitats, and geomorphic processes integral to the river and its biological diversity so that qualitative values could be assigned to their relative occurrence, and to various restoration techniques, cost and maintenance factors, and adverse impacts. Workshop participants were asked to test the matrix at home and to refine their choices relative to channel and floodplain activities, and overall water management. Completed matrices were totaled for a ranking of restoration activities in each of three reaches. The final product of the Conceptual Restoration Plan would eventually provide an overall restoration strategy with prioritized techniques and suggested project areas.

> *"Restoration opportunities for the San Acacia-to-San Marcial reach include providing a greater range of flow regimes, creating a more dynamic channel, removing constraints on natural channel processes, expanding the active floodplain, increasing channel-floodplain hydrologic connectivity, reformation of the channel geometry, and enhancement of the native riparian ecosystem. The restoration vision is defined by two primary goals: restore natural river function, and enhance riparian biological diversity." (Handout supplied by Tetra Tech, Inc. Infrastructure Services Group to attendees at the Socorro Save Our Bosque Task Force Planning Matrix Design & Component Workshop, June, 2003.)*

On June 24, members of the New Mexico Drought Task Force were told by the head of the National Weather Service's Albuquerque Office that nearly all of the state was in "severe hydrologic drought," with reservoir storage at its lowest since 1978. Furthermore, they were warned, "the most likely scenario is that the reservoir situation could be worse this time next year."

The next day, the story of the Middle Rio Grande bosque took a fateful turn. Sparked by illegal fireworks, a massive blaze broke out in the cottonwood forest just south of Interstate 40, in the very heart of Albuquerque. Charging northward along both sides of the river and fed by a half-century's downed wood and thick underbrush, the inferno threatened homes crowded along the bluffs, consuming one and a half miles of bosque on the west side, and another mile of riparian vegetation on the east side before fire department personnel from many jurisdictions managed to gain control. Unbelievably, only a single home under construction in an upscale subdivision called The Oxbow was lost to the fire. The good ending could be credited to several years' worth of cooperation between New Mexico State Forestry, and municipal, county, and tribal governments to train fire crews in tactics specifically geared to fight conflagrations in the bosque.

Before the smoke of the Atrisco Fire had lifted, however, a new fire broke out the next evening, north and south of the Montaño Bridge. Driven by erratic winds and aided by darkness, the monster raged for eight hours, coming dreadfully close to vulnerable neighborhoods, a shopping center, and the Bosque School, all built against the cottonwood ambience of the river's western flank. The story drew national news coverage, federal funds, and the appalled attention of the public, to whom the term 'bosque restoration' had previously meant very little. From distraught comments reported in the media, it was clear that Albuquerqueans believed a dense understory and continuous canopy were natural to their river forest. Those who knew better pointed to the *Bosque Biological Management Plan* and begged anew for a concerted effort to return the riparian corridor to an open mosaic.

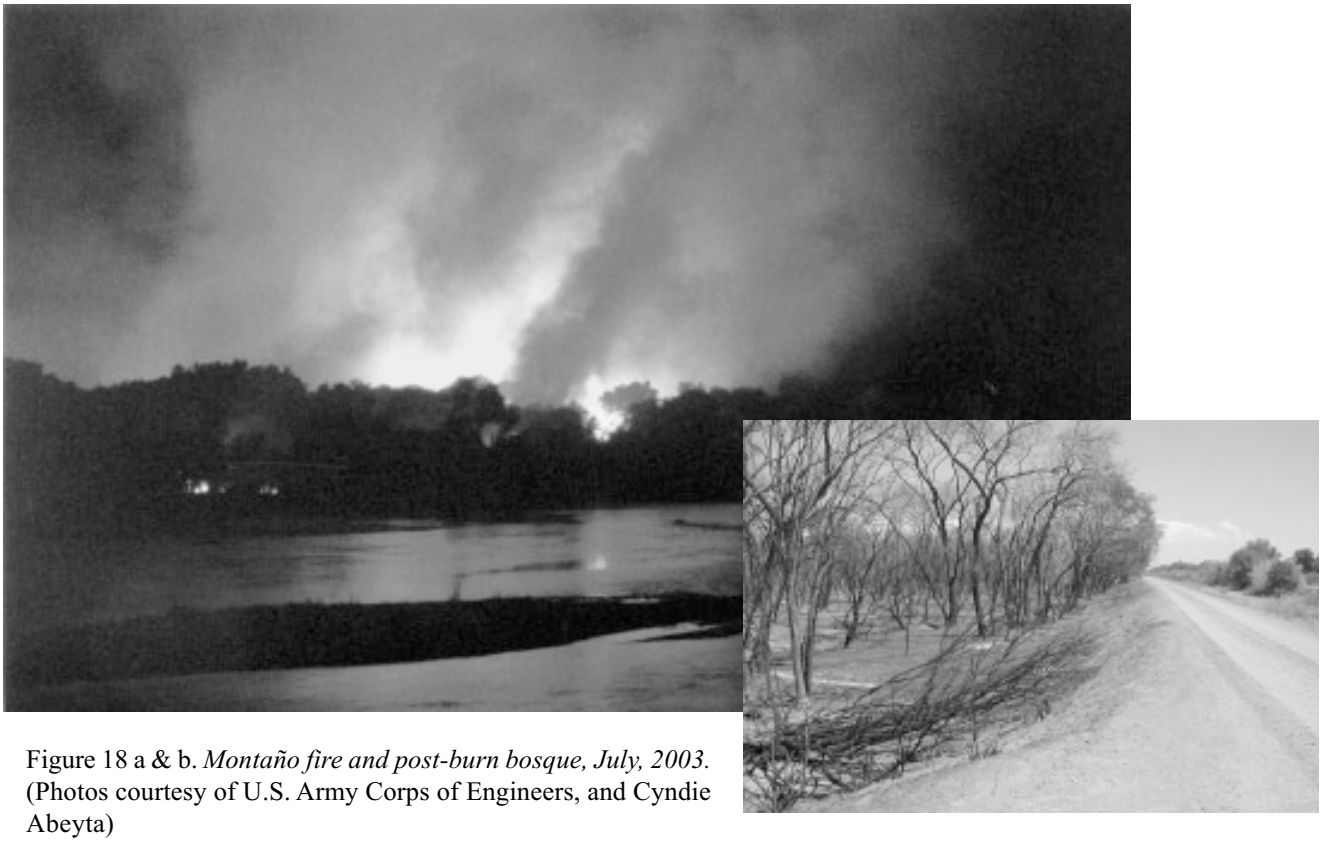


Figure 18 a & b. *Montaño fire and post-burn bosque, July, 2003.* (Photos courtesy of U.S. Army Corps of Engineers, and Cyndie Abeyta)

Albuquerque's $1.7 million refugium for the endangered silvery minnow took in its first guests at the end of June. The refugium—a regulated, artificial pool of water—houses adult silvery minnows, bred and grown in tanks at the nearby Albuquerque Aquarium.

Figure 19. *Albuquerque's Rio Grande silvery minnow refugium.* (Photo courtesy of Joel Lusk)

On the legal front, New Mexico congressional delegates attached riders to separate House and Senate spending bills in hopes of derailing the 10th Circuit Court of Appeals' decision regarding water for the silvery minnow. Both riders placed an exemption on San Juan-Chama contract water for endangered species use, and one of them designated Middle Rio Grande Conservancy District water off limits as well. Both bills passed their respective houses, though New Mexico Representative Tom Udall asserted that rather than evading the court ruling, management agencies ought to aim at improving water efficiency and identifying "additional sources" of water for species needs.

> *"The Senate rider would grant an exemption to every single facility and action in the Middle Rio Grande, including [the release of] effluent from the sewage treatment plants of Albuquerque and others, Albuquerque's huge new Drinking Water Project, discharges from Los Alamos National Laboratory and Intel, and everything else having impacts on the Rio Grande." (Letty Belin, Western Resource Advocates , Albuquerque Tribune, July 24, 2003.)*

In response to the devastating bosque fires, the U.S. Army Corps of Engineers convened a Bosque Wildfire Project to undertake restoration work that had already been granted Congressional authority and funding. The project area was to include the Albuquerque reach of the Rio Grande bosque, also known as Rio Grande Valley State Park; the Corrales Bosque Preserve; and locations on tribal land designated by the Pueblo of Sandia. Site work would include selective thinning of areas with high fuel loads and/or non-native plant species populations; removal of jetty jacks and debris; improvement of emergency access in the form of Riverside Drain crossings, levee road improvement and construction of turnarounds; and revegetation of burned and thinned areas. (www.bosquerevive.com)

Midsummer saw the first of the New Mexico Interstate Stream Commission's twenty-nine scheduled public meetings to gather input for a State Water Plan. The plan, intended to provide a policy framework for the ISC and the State Engineer, would be an ongoing, "iterative process," according to ISC Director Estévan Lopez, and those unable to make it to one of the meetings were invited to submit their comments via the Office of the State Engineer website.

On-line water information had become a staple for anyone trying to keep up with the times. On July 26, three unrelated postings appeared within moments of each other on the Middle Rio Grande Water Assembly list serve. One referenced a KOAT-TV news story about residents of Sinagua Road in Placitas who had in fact been 'without water' over the Fourth of July weekend because the well serving Cedar Creek Subdivision had gone dry. In response to the story, one frequent contributor to the list serve wrote: "A local builder is drilling a new well for a new house just above my fellow acequia *parciante's* farm on the border of Cedar Creek. [We] have had no water in our acequia since early June, and [my neighbor's] well is going dry, too. We are losing years of hard work establishing our orchards, vineyards, and perennial beds, only to watch them dry out and die."

Another list serve reader broadcast an Associated Press clipping from Las Cruces concerning a drought forum hosted by the Office of the State Engineer to gain public input for the State Water Plan. One hundred and fifty participants were asked to "imagine managing water without government" with the goal of making the supply last for generations. The top recommendations turned out to be reducing the state's population, substituting desert vegetation for lawns, and curtailing urban sprawl. Conserving water, revisiting the Rio Grande Compact, desalinating brackish water, and thinning overgrown forests were also on the list.

Finally, Water Assembly list serve subscribers were forwarded the results of a water quality survey of springs and streams flowing into the Rio Grande. Undertaken by The RadioActivist Campaign, Concerned Citizens for Nuclear Safety, Amigos Bravos, the New Mexico Environment Department, and Los Alamos National Laboratory, the investigation had reportedly confirmed the presence of low levels of radioactive cesium-137 in several mid-Rio Grande tributaries.

By the end of July, the Richardson administration announced it would initiate a system of water courts to address questions of water right ownership in New Mexico. With the majority of the state's water as yet unadjudicated and some fourteen percent of the State Engineer's budget going to litigation, it was believed the special courts would "help speed up the transfer of water rights."

Interest in the City of Albuquerque's improved xeriscape rebate program was increasing. On August 5, the *Albuquerque Journal* reported the city had issued $164,000 in rebates for 2003, in contrast to just $54,000 in 2001. At the same time, one city council member was calling for a reduction in municipal water rates until something was done about the system's "unaccounted for water." Municipal water rates had indeed risen to fund the still-unapproved Drinking Water Project. According to one North Valley resident's July bill, Albuquerque municipal water use was being measured in units of 748 gallons. For even one gallon more, the resident was charged for two full units, or $10.42. Included in that total was a base charge of $4.60; a facility rehab charge of $1.61; a state surcharge of $.05; a San Juan-Chama charge of $2.78; and a low use discount of twelve cents, leaving a commodity charge (the actual price of the water) of $1.50.

Concurrently, the *Albuquerque Tribune* carried a feature entitled, "Arid Field of Dreams," on unrestrained growth in Rio Rancho. "We're going to be bigger than Albuquerque by a significant amount," predicted the west side municipality's mayor, who dismissed water availability as a limiting factor. The article went on to outline the community's stringent water conservation program. A few days later, however, KRQE-TV's evening news reported that 200 million gallons of groundwater was being discharged down an arroyo so that Rio Rancho's water department could flush a city well. "It was just too expensive," one employee explained, "to pipe the water somewhere it could be used."

On Wednesday, August 6, Middle Rio Grande Water Assembly members received the following plea from fellow volunteer, Kevin Bean:

> "At a recent joint meeting of the Water Assembly's Action Committee and the Mid Region Council of Governments' Water Resources Board, we began to review and revise a narrative write-up of the draft converged scenario which contains the proposed suite of alternative actions needed to meet the regional water plan's mission, goals and objectives. We made several important changes.
>
> "One was to throw out the current 'no-drought' scenario version (i.e., 'normal' conditions), and replace it with a new 'no-drought' version based not on a mere fifty years of precipitation data, but on 2000 years of tree-ring data analysis. The result is a 'normal' precipitation condition that predicts fifteen to twenty percent less precipitation than the former 'no-drought' version based on only fifty years of data. This is a major change, and one that everyone present at the meeting agreed to. We still need to construct a scenario version based on actual 'drought' conditions.

"Based on the above change, the modeled Rio Grande Compact deficit under the draft scenario increases by nearly 500,000 acre-feet to a maximum of nearly a million acre-feet in the year 2015, and does not show a positive balance until the year 2040.

"A thirty-eight-year compact deficit that exceeds 500,000 acre-feet for a period of at least twenty-five years is unacceptable, and a regional plan that anticipates such a deficit will surely be rejected by the Interstate Stream Commission. (This projected deficit is based on the revised Sandia National Labs model that employs multiple runs of the model to obtain a median projection; it is not a worst-case scenario.)

"Faced with this looming 'short-term' deficit, I suggested at the joint meeting that we scrap the current agricultural section of the draft scenario that calls for no alteration in either crop acreage or crop type distribution, and replace it with, 'The state shall purchase and permanently retire the agricultural surface water rights needed to avoid defaulting on the Rio Grande Compact. This likely will decrease current agricultural acreage by fifty percent or more.'

"Although I qualified this suggestion as coming from a devil's advocate, it nonetheless produced a predictable response among some of those present at the meeting—one that can be summarized as, 'You'll take my water away when you can pry it out of my cold, dead fingers.'

"It also, however, served to focus attention on the still unresolved 'short-term' problem of the predicted compact deficit. Although the group elected, after much discussion, to leave the agricultural section of the draft scenario essentially the same, we decided to add to the plan a separate section calling for the identification and implementation of measures that will eliminate or mitigate the compact deficit problem, and we listed several possibilities, including leasing agricultural rights, adjusting the timing of implementation of the city's San Juan-Chama Drinking Water Project, greatly accelerating urban conservation efforts, greatly accelerating bosque restoration, and even INCREASING groundwater pumping to supplement river flows.

"We will work our way through the rest of the draft scenario categories, revise them as the group sees fit, and evaluate them against the mission, goals and objectives. Those categories are water banking, water quality, bosque restoration, constructed wetlands, instream flow, reservoir management (moving some storage upstream), desalination (in the Tularosa Basin), and transfers from Socorro and Sierra Counties.

"I am concerned, however, that it is insufficient to simply state in the plan that actions will be identified and implemented to address the 'short-term urgent problem' of the projected compact deficit. It is my position that before this plan is submitted to the public and to policymakers, it needs to contain specific alternative actions, the water savings from which can be quantified, that demonstrate how the current water budget deficit and the projected compact deficit will be corrected. This is not

something that can be put off until another day. As the devil's advocate, I suggested one such alternative but it was rejected out of hand. What, then, will we do instead?

"Let me add that one does not need to rely on the Sandia National Labs model to understand that we have a very serious and looming problem relative to the Rio Grande Compact. The Assembly's water budget and the Pappadopulos study concur on a current and ongoing annual budget deficit of 55,000 acre-feet. The region's foremost water experts (Mike Kernodle, Frank Titus, Steve Hansen, and others), concur that this deficit—currently obscured by groundwater pumping—will become obvious when the city's San Juan-Chama Drinking Water Project comes on line. Except for the last couple of decades, the state's history of compact compliance shows more years in deficit than in surplus.

"We have to bite this bullet, and there is no easy or painless way to do it."

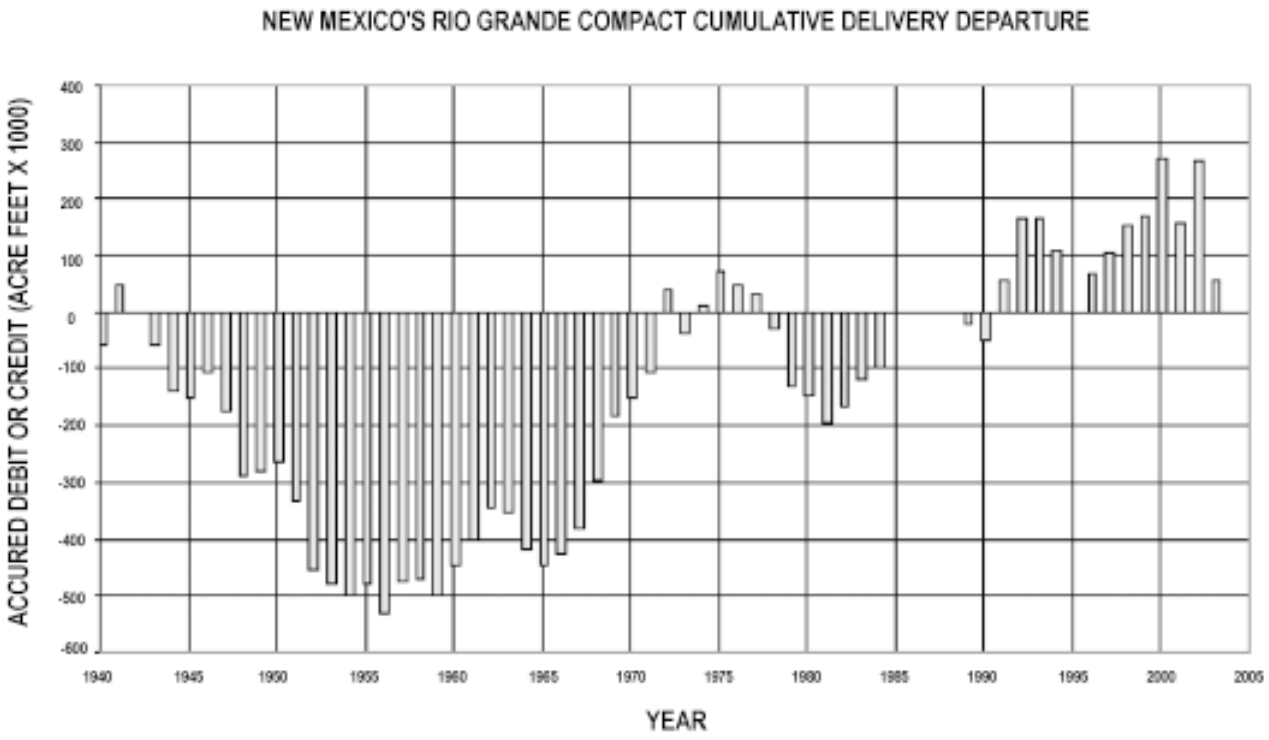


Figure 20. *Rio Grande Compact debits and credits, 1940-2005*. (Graphic courtesy of the Middle Rio Grande Water Assembly)

"Growth is the issue. We can transfer all the water from the farmers and from the bosque, such as Los Angeles has done. That has not led to balancing uses with supply, even with a large ocean next door. Rather, Los Angeles has drained other regions. Is that what our legacy of water planning is to be? USGS Report 03-4040 simulated three scenarios out to 2040 for our region. The results show a spreading of the groundwater depletion over a larger area, even with direct use of San Juan-Chama water. Unless we change our habits, that is the reality." (Elaine Hebard, e-mail to Middle Rio Grande Water Assembly list serve, August, 2003)

With water for its non-Indian constituents due to be shut off on August 11, the MRGCD announced that same day that once again, it would borrow City of Albuquerque San Juan-Chama water to extend the irrigation season. The extra 15,000 acre-feet would give farmers another two weeks, the news release said. It would also help meet the terms of the March 17, 2003 Biological Opinion (U.S. Fish & Wildlife Service, 2003) regarding flows for the silvery minnow. What was not celebrated in print was the MRGCD's escalating water debt to the city, which stood at around 130,000 acre-feet.

Also that week, the Department of the Interior held the eighth in a series of "regional consulting conferences" to discuss Water 2025, the federal initiative to "prevent crises and conflict" over water in the western United States. Bureau of Reclamation Commissioner John Keyes told an Albuquerque audience of more than three hundred that in many places, existing water supplies are simply inadequate to serve growing metropolitan populations, the prior rights of tribes and agriculture, and the needs of the environment. Interior, which is home to the Bureau of Reclamation, the U.S. Fish & Wildlife Service, USGS, and the Bureau of Indian Affairs, delivered a message to states, tribes, and local governments that they "have a leading role in meeting these challenges" and will need to leverage funds to help solve the problems. If conference attendees recognized a federal footprint relative to creating water overallocations in the first place, no one said so, though former New Mexico State Engineer and Bureau of Reclamation Commissioner Eluid Martinez expressed concern that in Water 2025, Reclamation might indeed be promising more than it could deliver.

Drafts of both the Conceptual Restoration Plan for San Acacia-to-San Marcial (Tetra Tech, 2004), and the Endangered Species Act Collaborative Program's Habitat Restoration Plan (U.S. Fish & Wildlife Service, 1999) were being circulated for review. The similarities were telling, perhaps because both groups had members in common, but also because information sharing was fostering a developing consensus about river restoration.

San Acacia-to-San Marcial Conceptual Restoration Plan

Using the decision-making matrix created for the Socorro Save Our Bosque Task Force by Tetra Tech, ISG, with input from its Oversight Committee, restoration techniques were ranked by workshop participants in May of 2003. The group's choices included:

- Spring flushing flows
- Eliminate structural limitations on flooding (*e.g.*, San Marcial railroad bridge)
- Manage future development
- Increase frequency/duration of flooding
- Remove exotic vegetation (selective and clear cut)
- Create wetlands and marshes
- Enhance groundwater storage and interaction

- Plant and seed native vegetation
- Create flooded bottomlands
- Variable floodplain topography
- Reconnect oxbow and old channels
- Destabilize and lower banks (terracing)
- Fall maintenance flows

The restoration techniques recommended in the final plan would not be limited to these options; the list illustrates, however, something of a preferred toolbox for redressing river function and biological diversity in the Socorro valley. The draft proposed restoration activities to address improved river-floodplain hydrologic connectivity and a diverse set of plant communities, including cottonwood/willow bosque, wetlands, saltgrass meadows, and grasslands. The Socorro Save Our Bosque Task Force also evaluated the potential for restoring this mosaic by managing a flow regime within existing administrative, legal and physical constraints to sustain a prescribed active channel.

> *"The highest rank was assigned to non-structural, resource management activities and the results were consistent from reach to reach. In general, floodplain activities were preferred over channel restoration activities. One surprising result was that channel maintenance activities such as disking and mowing open channel sandbars encroached with vegetation scored low. This particular channel maintenance activity may be required to limit the vegetation encroachment in the channel during successive dry years and may be a cornerstone of a channel adaptive management strategy." (San Acacia-to-San Marcial Conceptual Restoration Plan Draft, August, 2003.)*

ESA Collaborative Program Habitat Restoration Plan

With many caveats, the ESA Collaborative Program proposed a draft list of habitat restoration practices that "promise to improve silvery minnow and willow flycatcher habitat." The results tracked remarkably well with the essentials for river restoration.

- Terracing and lowering the river bank where the channel is incised and there is limited overbank flooding
- Constructing or reconnecting side or abandoned channels, wetlands and ponds, oxbows, and sloughs with the main channel
- Widening the channel
- Using gradient control structures to rebalance sediment loads and transport capacities
- Allowing for more woody debris in the channel
- Removal of elements that constrict the side-to-side movement of the channel
- River bar and island enhancement
- Cottonwood and willow recruitment, and control of invasive exotics
- Manipulation of the magnitude, timing and duration of flows, and the frequency of floods

"The ESA Collaborative Program is addressing the needs of two species in the context of the hydrology, geomorphology, and biology of the Middle Rio Grande. From that perspective, the signatories will also be addressing improvements to processes of the river that will benefit the ecosystem as a whole. I believe many working within the Collaborative Program acknowledge that if we do not look at the river as a whole, we will not accomplish the goals of the program, and in the long run, we will all lose." (Gina DelloRusso, co-chair, ESA Collaborative Habitat Restoration Subcommittee and Refuge Ecologist at Bosque del Apache National Wildlife Refuge, personal conversation, 2003.)

Monsoon season was passing by without much promise. On the other side of what local weather forecasters call "the central mountain chain," wells were drying up. As anxiously observed by the *East Mountain Independent* the week of August 26, "Well drillers, water haulers, government officials and homeowners report the area's groundwater supply problem is widespread and getting worse. They say that those lucky enough to find water are drilling ever deeper to get it, and that once highly productive wells are becoming marginal." More ominous still, Tijeras Creek had ceased to flow "for the first time in decades."

Down in the basin to the west, MRGCD irrigators between Cochiti and Isleta Pueblos received an unprecedented letter from the Bureau of Reclamation. "Sometime during Labor Day Weekend," it said, "the Middle Rio Grande Conservancy District non-Indian water users will no longer have any stored water available for the remaining 2003 season. The Six Middle Rio Grande Pueblos have prior and paramount rights to irrigate 8,847 acres. The water remaining in the irrigation system will serve the prior and paramount rights of Cochiti Pueblo, Santo Domingo Pueblo, San Felipe Pueblo, Santa Ana Pueblo, Sandia Pueblo, and Isleta Pueblo...Extra measures are being taken to ensure delivery to the pueblos and to monitor and identify non-authorized use by junior users. If necessary, appropriate legal remedies will be pursued by federal government officials."

Simultaneously, the University of New Mexico's Water Resources Program and the Law School's Utton Transboundary Resource Center announced an upcoming speaker series on "Water Issues for the 21st Century." Topics included, "What Drought and Climate Change Mean to New Mexico," "New Mexico's Interstate Water Compacts," "U.S./Mexico Water Issues," and "New Mexico's Water Future."

As September and the ten-year anniversary of the *Bosque Biological Management Plan* approached, these were the subjects that disturbed the sleep of the water-minded in the middle basin. Key outcomes remained uncertain: prior rights were ominously unquantified; there was still no ruling on the protested application by the City of Albuquerque to divert up to 48,200 acre-feet of San Juan-Chama water from the Rio Grande for urban consumption; title to (and thus control of) the crucial works of the MRGCD was still in dispute; and there was likely more to come in the sustained conflict over silvery minnows. Despite all the scholarship, cooperation, and substantive work of the preceding decade, it seemed the fate of the Middle Rio Grande 'ecosystem' would ultimately hinge on a handful of political decisions.

Epilogue…2004

At the end of 2003, a final draft of the Middle Rio Grande Regional Water Plan (Middle Rio Grande Water Assembly, 2004) was completed and presented for review to agencies and local governments. Resolutions of Acceptance were passed by the municipalities of Albuquerque, Belen, Bernalillo, Bosque Farms, Corrales, Cuba, Jemez Springs, Los Lunas, Los Ranchos de Albuquerque, San Ysidro, Rio Rancho, and Tijeras; Bernalillo, Sandoval, and Valencia Counties; the Albuquerque Metropolitan Arroyo Flood Control Authority and

the Southern Sandoval Arroyo Flood Control Authority; and Cuba Soil and Water Conservation District and the Middle Rio Grande Conservancy District. In August of 2004, the New Mexico Interstate Stream Commission formally accepted the Middle Rio Grande's regional water plan.

The four hundred-page document offered a collection of non-compulsory strategies and policies for preserving and protecting water resources, with a focus on the availability of "wet water," and on ways to begin mitigating the past and present regional deficit. Alone, none of the forty-three recommendations provide a solution to the region's water problems. Together, however, they point the way toward more sustainable water use. With the completion of the plan, the Memorandum of Understanding between the Mid-Region Council of Governments and the Middle Rio Grande Water Assembly was formally dissolved, and the all-volunteer Water Assembly was reorganized to help foster the water plan's dissemination and implementation.

Another initiative, the Strategic River Reserve, made its legislative debut in 2004. Developed by a bipartisan policy research group, Think New Mexico, the measure would have authorized a pool of publicly held water rights for each river system in the state, to be used to meet legal challenges from neighboring states, federal mandates, and general fluctuations in water availability. Written in close consultation with the New Mexico Interstate Stream Commission and State Engineer, the bill was amended to prohibit the condemnation of water rights, and to ensure that any unneeded water would be returned to the source use and location and could not be re-marketed to cities. The measure earned broad acceptance among water user groups, cleared the House floor by a substantial margin, and was nearing a Senate vote when the 30-day session ended. (Ultimately, the Strategic River Reserve would pass the 2005 legislative session with a capital outlay of $2.8 million.)

The first signs of implementation were underway on an embryonic State Water Plan. In late May, the Office of the State Engineer circulated a draft of proposed regulations for Active Water Resource Management (AWRM), one of the strategies mandated by the legislature in 2003. Intended to "provide a consistent statewide framework for priority administration" and to "bring all administration of water within New Mexico under one common umbrella," the regulations called for the creation of water districts conforming to stream systems and/or groundwater basins statewide, with appointed watermasters to administer the resource according to priority. Rules specific to each basin were to be negotiated. Opposition to AWRM was intense. *Acequia* and agricultural interests, tribal governments, municipalities, the business community, environmentalists, property right advocates, and regional water planners all submitted fuming annotations to the sixteen-page proposal. Common criticisms were that the regulations violated due process and were very likely unconstitutional because they amounted to adjudication of water rights by the State Engineer without a hearing. The state promised to revise its draft.

Regional anxiety about meeting Rio Grande Compact obligations in the dry years to come—and what water would be requisitioned to make up the deficit if the state found itself in arrears—was the topic at the Annual Middle Rio Grande Water Assembly in June. Despite admonitions from the state that compact compliance need not concern regional water planners, veterans of the Middle Rio Grande planning process feared otherwise. Presentations by USGS, Sandia National Labs, the Bureau of Reclamation, the New Mexico Interstate Stream Commission, the Office of the State Engineer, and various water user groups shaped a disquieting picture of the middle basin's future. With no water right adjudication on the horizon, an epidemic growth contest underway between the two largest municipalities in the region, and past and present aquifer mining only beginning to have long-term effects on the fully-appropriated river, just whose "ox would get gored" in the event of a compact shortfall indeed seemed a subject worth exploring.

"The ISC's Regional Water Planning Handbook says of the purpose of regional water plans," New Mexico statutes provide that for a state to prefer its own citizens over an out-of- state appropriator, there must be a show of need within the state, and a feasibility of supplying that need from particular sources." That citizenry includes Indians living within New Mexico. As I have proposed and still advocate, all three states within the Rio Grande watershed [Colorado, New Mexico and Texas] should bear the responsibility of meeting the water rights of the Pueblos and tribes. Given the overwhelming opposition to that viewpoint of sharing, and New Mexico's apparent willingness to bear the burden of meeting the water needs of the tribes within its borders, perhaps giving the Indians all the water that can be supported as theirs to use would provide water that would not or cannot be expected to be delivered to Texas because of the Indians' exclusion from meeting Compact requirements." (Blane Sanchez, to the Middle Rio Grande Water Assembly on "Meeting the Urgent Shortfall Reality," June, 2004.)

In July, the City of Albuquerque was granted its permit to divert San Juan-Chama water for direct municipal use by way of an inflatable dam on the Rio Grande just downstream of the Alameda Bridge. As a result of the protest lodged by agricultural and environmental interests, a number of conditions were attached to the diversion permit, which called for improved accounting of Rio Grande return flows and San Juan-Chama carriage losses; an increased flow threshold through the Albuquerque reach; and a reduction in the city's per-capita water consumption to 175 gallons per person per day by the time the project went on-line, and 155 gallons per person per day within twenty years. Construction on the project was already underway, but as the city prepared to install a massive pipeline to transport the diverted water to a planned treatment facility, it encountered fresh resistance on behalf of a swath of bosque cottonwoods and a residential street in the North Valley, both of which lay in the pipeline's path. Legal protest of the project continued, too, as the agricultural and environmental coalition filed an appeal of the State Engineer's decision in District Court on grounds that the diversion still posed a threat to senior water rights, to the riverine environment, and to the state's ability to meet Rio Grande Compact deliveries.

***B**osque Biological Management Plan* lead author Cliff Crawford and Middle Rio Grande Conservancy District biologist Sterling Grogan presented a proposal for Bosque Landscape Alteration at a workshop hosted by the University of New Mexico's Utton Center in September. Objectives of the proposal included reorganizing the Rio Grande bosque landscape—within current constraints—to retain its historical processes and wildlife communities; to recreate the river's former patchy mosaic of native trees and open spaces along the present narrow floodplain while containing the distribution of invasive species; and to reduce the intensity of bosque wildfires and water depletion by bosque evapotranspiration. To accomplish the work, the following were seen as basic requirements:

- To become familiar with the present condition of the bosque landscape, including the existing evapotranspiration rates and fire danger in different reaches, and with the management practices that affect it

- To develop flexible hydrological management options, including the ability to mimic the natural hydrograph, in order to maintain wet soils at appropriate seasons for native tree recruitment and maintenance

- To recognize that historical flooding is being replaced by wildfire as the driving force behind current bosque landscape dynamics, and implement flexible responses to both flood and fire to maximize the benefits/minimize the damages of these disturbances

- To manage the river and the anticipated patchy riparian mosaic for habitat diversity, understanding that biological diversity will follow

- To develop criteria for evaluating the desired evapotranspiration rates and fuel loads for different reaches of river to achieve the greatest diversity of habitats using the most appropriate techniques

- To construct wetlands inside – and where possible outside – the levee system, with reference to available wetland models

- To maintain the altered bosque landscape with measures that reduce evaporation from soil surfaces, minimize depletions and provide for overall reductions in the consumptive use of the riparian ecosystem

- To ensure a sustained program of bosque research and monitoring

Meanwhile, applications to transfer paper water rights from beyond the Middle Rio Grande's hydrologic borders to offset increased groundwater pumping in the region continued to cross the desk of the State Engineer. One in particular—the proposed transfer of 652.20 acre-feet per year of groundwater rights from Sierra County below Elephant Butte Reservoir to the municipality of Rio Rancho, 150 miles upstream—suggested the desperation of both urban developers and the state in trying to find water to keep the growth balloon afloat. A number of protests were filed against the application, including one from the Pueblo of Sandia, whose undetermined senior water rights remained vulnerable to impairment in the Middle Rio Grande.

On November 23, the *Albuquerque Journal* reported that Congress would allocate $6.15 million to the Middle Rio Grande Endangered Species Act Collaborative Program, down from the previous year's $7 million. Two million was earmarked for the purchase or lease of water; $2,000,000 would be used for habitat restoration; $500,000 would go to science and monitoring efforts; $275,000 would be used to improve water and minnow management; $750,000 would ensure that stipulations of the 2003 Biological Opinion are met; and $625,000 would go to program management. Shortly thereafter, the Bureau of Reclamation would up the management budget to $1.3 million.

In early December, S.S. Papadopulos & Associates released the third and final phase of the Middle Rio Grande Water Supply Study contracted by the New Mexico Interstate Stream Commission and the U.S. Army Corps of Engineers (SSP&A, 2004). The subject was groundwater-surface water interaction in the Middle Rio Grande and its possible impact on the state's ability to meet future Rio Grande Compact deliveries. The long struggle to get water management entities to account for the critical-but-unseen connection between groundwater pumping and river flow seemed at last to be bearing fruit: unequivocally, the new report indicated that 'renewable' supplies of both surface and groundwater were inadequate to meet current demand. Assuming a variability in climate similar to that of the past fifty years, and continued water use at present levels, SSP&A's probabilistic analysis suggested that Rio Grande Compact debt could be expected to occur in three out of every five years, and that even with the immediate and unlikely implementation of *all* alternatives put forth in the Jemez y Sangre, Middle Rio Grande, and Socorro-Sierra Regional Water Plans, the water supply situation in the middle basin could not begin to improve until the year 2040.

The winter of 2004 proved to be an exceptionally wet one, although forecasters warned that the welcome moisture in no way spelled the end of the drought. Once again, variability--a characteristic of arid regions that repeatedly argues for prudence and resourcefulness--seemed to be offering the Middle Rio Grande region an opportunity to mend its ways.

Part Two: An Ecosystem Approach

"These days we are well aware of our obligation to take care of certain elements within specific ecosystems…But taking care of individual species is not so easy. What we have learned over the years is that in managing ecosystems, attempts to maximize individual variables in those complex, multi-variant systems tend to cause the system to falter and crash. It doesn't matter really what that variable is. It might be board feet of lumber. It might be animal unit months of grazing. It might be spotted owls. The bottom line is that if you are pushing for just one variable, you will place the entire system at risk and you are going to get into trouble." (Bill deBuys, presentation to the Middle Rio Grande Bosque Consortium, November 5, 1991.)

"Our whole society was built on the notion that we could and must control nature...But natural systems are the consequence of a long evolution, and ecology is teaching us that we must first understand these systems to see how far we may modify them for our benefit without disastrous consequences. This is a new point of view that arose with ecological science, that world systems have a functional reality of their own and that if we push them too far, the systems will either break down, or backfire." (Environmentalist Roland Clement, in "Water Wars" by Diane Raines Ward, 2002.)

"...ex situ methods will save a few species otherwise beyond hope, but the light and the way for the world's biodiversity is the preservation of natural ecosystems." (The Diversity of Life, Wilson, 1992.)

"It should have been the Endangered Ecosystem Act, not the Endangered Species Act." (Cliff Crawford, personal conversation, 2002.)

The listing of the Rio Grande silvery minnow as an endangered species in 1994 resulted in a schism in thinking relative to environmental restoration in the Middle Rio Grande. The legal mandate to protect a single species took immediate precedence over the more encompassing approach represented by the *Bosque Biological Management Plan*. Divergence from a holistic perspective eventually polarized public opinion, initiated a chain reaction of lawsuits that set resource agencies against each other, and exhausted critical reserves of water to effect uninterrupted river flows.

We are beginning to recognize that the focus on single species restoration has sent us on a costly ten-year detour, and that rather than doctoring the symptom—i.e., trying to halt the decline of one or two species—the wiser course is to protect the system's natural hydrologic processes, for they are key not only to the health of the river, but to the well-being of all of its attendant species. Although endangered species concerns are still driving ecological appropriations and efforts, the actions currently being proposed for recovery of the silvery minnow are starting to echo the strategies charted in 1993 to revive the Rio Grande bosque: U.S. Fish & Wildlife Service's Biological Opinion now proposes both water and non-water solutions, including the restoration of riparian habitat along the river. Gradually, inexorably, we are moving toward an ecosystem approach.

"An 'ecosystem approach' includes both biological and non-biological parts of the system. For a large river system like the Rio Grande, which has exotic species problems,

endangered species problems, and a natural interannual hydrologic variability exacerbated to some extent by human activity, you have a lot of complex factors in play. If you don't assess all of them, if you only look at one piece of the puzzle, you're not going to be able to understand the role of any one piece. In an ecosystem approach, you start with climate and hydrology, link that to both in-river and riparian ecology, and then try to understand how these interact with human intervention and human activity. (Cliff Dahm, University of New Mexico Department of Biology, personal conversation, 2002.)

Kissimmee River Restoration

Restoration of the Kissimmee River ecosystem employs a systematic approach that includes planning, construction and implementation, performance assessment, management of the system, and widespread dissemination of the results.

Conceptual modeling is used to identify what is known about the system, what is not known, and what research needs to be undertaken. Site assessments and cost estimation further refine the planning process. Project design, construction, and implementation all demand good communication between scientists and engineers so that essential requirements for ecosystem health can be provided with a minimum amount of physical modification. 'Adaptive management' allows critical projects to go forward immediately, even as data is being collected and refined. Once the project is complete, monitoring continues to determine whether goals have been met, and to make needed adjustments to restoration activities. Feedback provided by periodic evaluation helps to refine both predictive models and restoration methods. Lessons learned are shared so that others engaged in ecosystem restoration can avoid costly mistakes.

In tandem with physical action, some measure of 'integrated governance' is critical to successful ecosystem restoration. Without buy-in from those entities with jurisdiction in the project area, holistic management is impossible because "the environment, society, and economics are not discrete systems, but related and interlinking subsystems." In the South Florida model, a task force was created to "coordinate the development of consistent policies, strategies, plans, programs, and priorities for addressing the concerns of the ecosystem."

The South Florida model's overall goals are to restore natural hydrologic functions by addressing issues of water quantity, quality, timing, and distribution; to restore and enhance the natural system relative to habitat and species diversity; and to "transform the built environment" by balancing human needs with the needs of the natural system, ensuring that resource-dependant industries such as agriculture, tourism, development and manufacturing are compatible with restoration goals. (Success in the Making— An Integrated Plan for South Florida Ecosystem Restoration and Sustainability, South Florida Ecosystem Restoration Task Force Working Group, 1998.)

The Kissimmee River Restoration Project in southern Florida is an exemplary model for holistic restoration. It involves a huge number of participants—some fifty-eight agencies, organizations, and individuals, with a clear lead agency, the South Florida Water Management District, as well as an independent external advisory committee that periodically assesses both the restoration work and plans for future activity in the basin. A group of five nationally known researchers make up the advisory committee. They include one expert

who assesses the biological integrity of river systems, one who studies southeastern rivers and wetlands, an ornithologist, a wetland vegetation expert, and a fisheries expert. On a semiannual basis, the team is brought in to listen to presentations, spend time in the field, and offer feedback to further guide the Kissimmee restoration. University of New Mexico ecologist Cliff Dahm serves on the Kissimmee advisory committee, and believes the ideas embodied in Florida could be very useful on the Rio Grande. "If you can begin to get the hydrology right," he says, "you're more likely to solve the other problems."

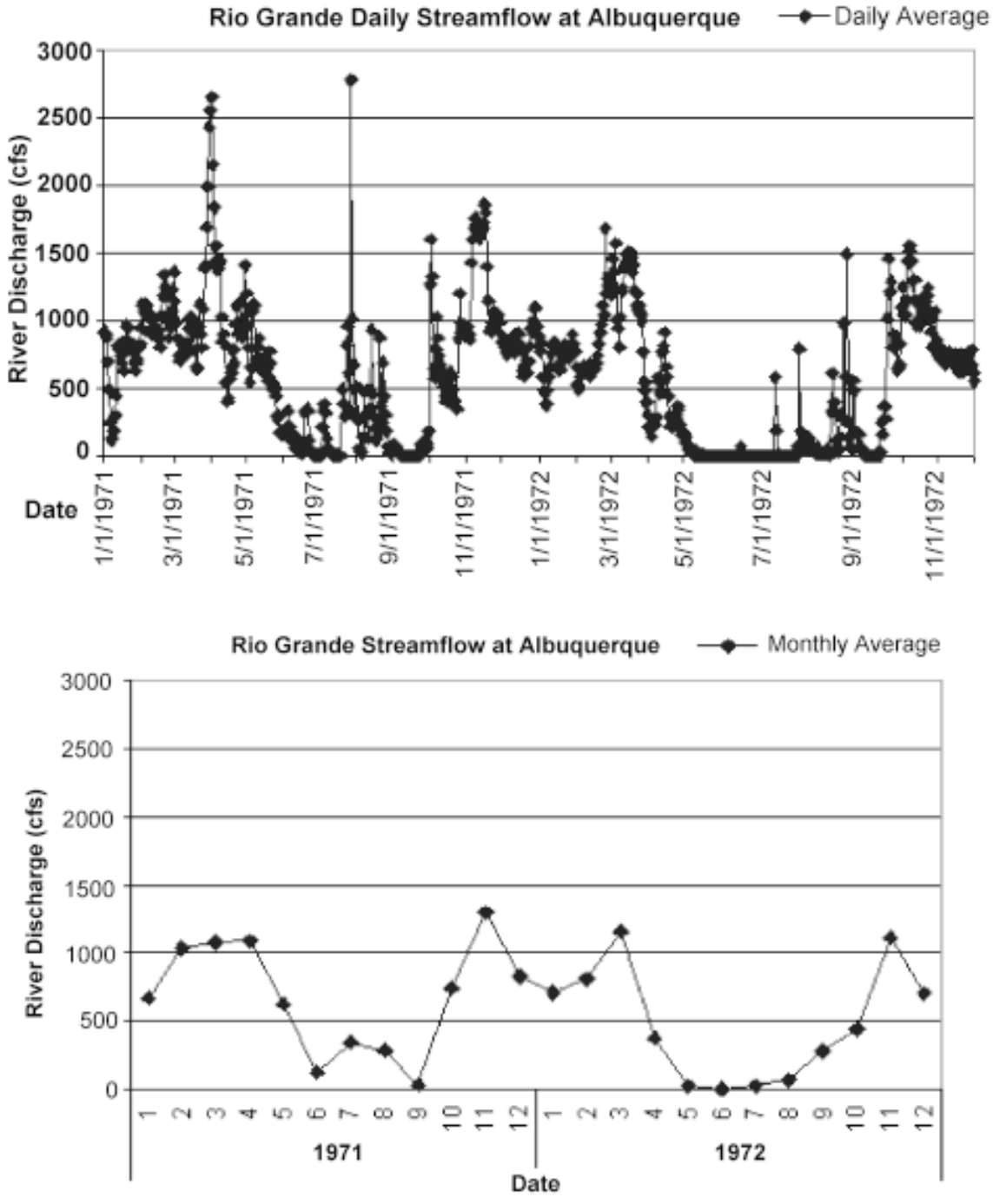


Figure 21 a & b. *Monthly averages can camouflage critical extremes: daily vs. monthly Rio Grande streamflow at Albuquerque, September, 1971.* (Hydrographs courtesy of Kim Eichhorst Mitchell)

But what, exactly, constitutes the Middle Rio Grande's 'right' hydrology? First, it must be recognized that due to the human imprint—dams, levees, floodplain development, aquifer pumping, and altered patterns of annual flow—the present river system is by no means natural. To return to some idealized 'original' state is not possible if human occupation is to continue in the basin. Instead, indispensable stream processes must take place largely within the constraints dictated by past engineering and contemporary demands.

A useful assessment of the region's climate and hydrology can be found in the *Bosque Biological Management Plan*. The climate is arid-to-semiarid, and seasonal precipitation is highly variable, with an average of less than ten inches of moisture a year, delivered for the most part as runoff from winter snows and summer monsoons. The extremes that make up that modest average are more important than the average itself. The management plan's authors note that precipitation in the region exceeded seventeen inches in 1941, while in 1956, only three inches fell.

Since the *Bosque Biological Management Plan* was written, climatological research suggests such broad oscillation could become even more pronounced. The U.S. Geological Survey is beginning to discern other patterns in ocean temperature that, coupled with the El Niño/La Niña phenomenon, appear to drive regional precipitation over the long term. What effect global climate change might have on such patterns is unknown. At the same time, tree ring data now offers an unequivocal glimpse into the past, attesting to reoccurring periods of severe thirst across the entire Southwest that often forced human inhabitants to abandon their home ground or die.

> *"Since the mid-1970s, the population has exploded in the Southwest during what researchers believe was one of the wettest two-decade stretches in the past 2,000 years. Now, they say, the climate may be shifting into a drought that could last for decades." (John Fleck, Albuquerque Journal, June 22, 2003.)*

How the river system responds to maximums or minimums of rain or snow is initially determined by geology. The mid Rio Grande valley is comprised of a series of depressions, compliments of a thirty-million-year-old rift in the earth's crust. Natural partitions in the form of intrusive lava flows occur at San Felipe, Isleta, San Acacia, and San Marcial. For about the last five million years, ancestors of the present stream and its tributaries have been filling this chain of basins with sediment weathered from the Southern Rockies. Stowed along with a puzzle of deposited sand, clay, and gravel is subterranean water.

> *"Ground water flows in narrow fractures in rock, where these are present, and in some places it occupies caverns and connecting passages. But in general, ground water is stored in the pore-spaces between the grains in deposits of sediment, and moves by seeping slowly through the pores. The great aquifer of the Middle Rio Grande Basin is a stack several thousand feet thick of irregular beds of various mixes of sand, silt, clay, and gravel, with no open spaces larger than the pores between mineral grains. (Hydrologist John Shomaker, "Myths, Mysteries and Misunderstandings," from an unpublished report to the New Mexico Interstate Stream Commission, 1999.)*

Such water-bearing deposits are exceedingly important to the Rio Grande for they constitute a hydrologic savings account that serves as the foundation for surface flow. When the system is functioning properly, water is "banked" in every wash and valley from the top of the drainage basin to the bottom.

Figure 22. *Rio Grande uplands near Heron Reservoir.* (Photo courtesy of the U.S. Fish & Wildlife Service)

> *"Since riparian ecosystems are in the bottomlands of a watershed, changes in how sediment and water run off of surrounding landscapes impact them most. A disturbance in any part of a watershed will create disequilibrium that will ripple through many ecosystems within the watershed, possibly influencing the condition of the watershed's riparian ecosystem for many years." (Riparian Ecosystem Recovery in Arid Lands, Briggs, 1996).*
>
> *"The physical characteristics of a stream channel—its dimension, pattern and profile—are all relics of the watershed which produced it, for if any of the factors which affect a watershed's balance are disturbed, the channel compensates. The tendency to stabilize is called dynamic equilibrium, and it follows the basic laws of physics and the natural properties of soil and water. This cause and effect relationship is often overlooked until we experience its consequences: erosion, catastrophic flooding, impaired water quality, or reduced water yield." (Jeff Whitney, U.S. Fish & Wildlife Service Rio Grande Coordinator, New Mexico Water Dialogue, October, 1997.)*
>
> *"The fastest way to destroy a river system is to degrade its watershed." (Environmental geologist John Hawley, to members of the Middle Rio Grande Water Assembly Action Committee, October 15, 2003.)*

Middle Rio Grande health therefore begins in the canyons of the Jemez and the Sangre de Cristo Mountains; in the arroyos that drain the basin's western escarpment and eastern llano; and in tributaries, ephemeral and perennial, from Cuba to the confluence of the Rio Puerco. Because the influence of these subordinate waterways extends all the way to the bottomlands of the mainstem, upland conditions have to be considered in tandem with rectification projects in the floodplain. In semiarid country, natural drainage patterns and recharge areas should serve as the backbone of land use planning; instead, humans repeatedly confound the 'sponge' function of the watershed. The land's potential to absorb precipitation and release it slowly downstream is compromised where canopy forest and understory are allowed to become too dense; where invasive woody vegetation crowds out water-saving native grasses; where roads, recreation, or overgrazing on steep slopes strip groundcover and invite erosion; where development's impervious surfaces block percolation and facilitate rapid runoff; and where man first ambushes the hydrologic cycle with wells, pumps, hoses, and sprinklers.

Figure 23. *Erosion in the Rio Puerco drainage.* (Photo by Lisa Robert)

> *"One of the most remarkable changes in southwestern landscapes involved late nineteenth and early twentieth century channel entrenchment. Between 1865 and 1915, arroyos developed in alluvial valleys of the southwestern United States across a wide variety of hydrological, ecological, and cultural settings. That they developed more or less simultaneously has encouraged the search for a common cause, some phenomenon that was equally widespread and synchronous. As with most recent environmental changes, whether global or local, efforts to understand arroyo genesis have been hindered by the inability to discriminate between natural and cultural factors. Much debate has focused on the regional and local causes for historic arroyo-cutting (Bull 1997). Range managers have been quick to point to the removal of plant cover by livestock, whereas climatologists have naturally looked to the skies for an explanation. The geologist, accustomed to studying the products of erosion over long periods of time, sees arroyos as symptomatic of inherent instability in arid landscapes, while acknowledging that geomorphic thresholds may be exceeded with changes in climate and vegetation. Following arroyo initiation, two of the more pervasive impacts on southwestern watersheds have been deterioration of wetlands and degradation of streamside vegetation caused by groundwater withdrawal and urbanization." ("Landscape Changes in the Southwestern United States in U.S. Geological Survey, Perspectives on the Land Use History of North America—A Context for Understanding Our Changing Environment," Allen et al., 2003, http://biology.usgs.gov/luhna/chap9.html)*

Throughout the Rio Grande drainage, upland grasses have suffered the greatest reduction of any component of the natural system save wetlands. Local soil disturbance and large-scale terrain rearrangement, injudicious grazing, and years of fire suppression have fostered more woody growth than can reasonably be supported in a semiarid climate. Land management agencies are working to thin overcrowded stands of piñon-juniper and ponderosa, but at lower elevations, programs to 'eradicate' saltcedar and Russian olive obscure the negative effect of other rampant species such as Siberian elm. Overall and throughout the watershed, a better balance needs to be struck between tree cover and grasslands.

River Processes — A Page From the Bosque Education Guide

The landscape of our planet has developed by the interaction of two opposite forces: the force of erosion, wearing away landforms, and the geologic processes that build landforms, generally through volcanism and mountain building. Running water is the most important of the forces of erosion. Year after year, streams and rivers erode and move an enormous amount of rock, sand and gravel from topographically high areas and deposit it in topographically low areas.

The same stream can: 1) carry and transport material that was eroded elsewhere; 2) erode its own channel and banks; and 3) deposit material along its channel and banks. Whether the stream does one or more of these depends upon the amount of water in the stream and the gradient of the stream channel (the difference in elevation between the beginning and end of the stream).

Streams adjust themselves as changes occur in their channel and their gradient and in the velocity of their water. Streams attempt to maintain a constant gradient by increasing or decreasing stream velocity, which affects the deposition or erosion of sediment, which in turn affects the depth and width of the stream channel. As the velocity of the water increases, the size of the material that can be carried by the water and the energy of the stream increase.

Monitoring the volume and velocity of streams is very important in order to understand how much water is available downstream for agriculture, cities, flood control and other uses. The very first river gauging station built by the U.S. Geological Survey in 1889 was in New Mexico, at Embudo Station on the Rio Grande south of Taos. (Bosque Education Guide, Morris et al., 2003, p. 383.)

> *"Variability is responsible for surface flow in an arid climate like New Mexico's. Without variability in precipitation and evapotranspiration, no water would make it to the surface. One might entertain the idea that a river only exists as a residual. It is the water allowed to stay on the ground after recharge and evapotranspiration have taken their share. The river is essentially what is left over." (Hydrologist John Shomaker, to the University of New Mexico Water Resources Basin Survey Class, August 28, 1992.)*

As a snowmelt hydrograph river, the Rio Grande's natural peak flow generally occurs in mid-May to early June with the melting of mountain snowpacks. Additional peaks due to heavy thunderstorms are also a part of the normal hydrograph, generally occurring in midsummer through late September. Conversely, there are times when downstream reaches of the river go completely dry.

Humans have always endeavored to cope with such extremes, and after a hundred years of tinkering and technology, the present river is essentially a plumbing system, dependent on a suite of man-made lakes. Heron, El Vado, Elephant Butte, and Caballo Reservoirs store water for irrigation and municipal use, while Abiquiu, Cochiti, Galisteo and Jemez Canyon Reservoirs were designed to check floodwater and contain sediment. The Rio Grande's present flow regime originates at the dam control structures of these various reservoirs, and a convoluted medley of state and federal mandates govern all reservoir operations.

Overall, water management has resulted in a reduction of peak river discharges through the middle valley, with large flood events being impacted the most, except those originating in the Rio Puerco or Rio Salado drainages. At the same time, there has been an increase in average daily flows, due in part to the presence of San Juan-Chama Diversion Project water in the system (ESA Workgroup Technical Summary on Hydrology, 2002), and pumped groundwater that enters the river as City of Albuquerque wastewater discharge.

Various policies and laws that figure into basin water operations are sometimes at odds with prudent timing and conservation of flows. According to the terms of the Rio Grande Compact, if the amount of useable water at Elephant Butte falls below 400,000 acre-feet, no native water may be stored in upstream post-1929 reservoirs and runoff from the highlands must be passed down the river to one of the most highly evaporative bodies of water on the continent. In a similar vein, adherence to the particulars of the Endangered Species Act can also result in contraindicated actions, as with the 2002 release of a substantial amount of the water in upstream storage at the height of a multi-year drought in an attempt to keep one stretch of sandy riverbed wet for silvery minnows.

The Rio Grande's natural hydrograph implies a very different 'strategy.' The whole system drinks deep during times of peak flow. Floodwater, with its freight of sediment and nutrients, overtops channel banks and spreads out across the accessible floodplain, ferrying soil to new resting places, nourishing riparian vegetation, filtering impurities, promoting plant propagation and decomposition, and funding the connection between surface flow and groundwater. As the flood recedes, slow-drying backwaters maintain native species through the dry summer months, and essentially, the system coasts, camel-like, until stream flow is renewed during the monsoons. High flows are thus necessary if the river is to complete its key tasks, and human interference with this single hydrologic characteristic hinders all of the forenamed processes.

Low flows, too, are undoubtedly important to the Middle Rio Grande ecosystem. Given natural seasonal cycles of high and low flow, and longer-term cycles of drought, some species that have evolved in the basin may well *require* periods of low or no flow, but little mention of that concept appears in the multitude of studies done on the riparian corridor.

> *Low (base) flows provide adequate habitat space for aquatic organisms; maintain suitable water temperatures, dissolved oxygen and water chemistry; maintain water table levels in the floodplain and, soil moisture for plants; provide drinking water for terrestrial animals; keep fish and amphibian eggs suspended; enable fish to move to feeding and spawning areas; and support hyporheic organisms (living in saturated sediments). Drought level low flows enable recruitment of certain floodplain plants; purge invasive, introduced species from aquatic and riparian communities, and concentrate prey into limited areas to benefit predators." (Rivers for Life, Postel and Richter, 2003.)*

Sediment transport is as important to overall hydrology as stream flow. Wherever water is slowed down, diffused, or restricted, sediment settles out. A sediment-laden, arid-climate stream's natural inclination is to meander from side-to-side, building the channel bed higher and higher until the water is forced to seek another route, whereupon the old course is abandoned to the status of backwater, slough, yazoo, or oxbow. From the river's point of view, there are periods of great accomplishment and periods of delay, and an essential factor in system health is the stream's latitude to drop what is held in suspension and then to either bypass such self-made obstructions, or to take them up again with renewed volume. The inability of the river to move freely across a generous floodplain alters its load bearing and distribution potential. The Rio Grande is currently confined to the narrowest possible channel within a reduced floodplain, and obstructions such as river crossings, jetty jacks, and banks armored with vegetation further impede the movement of sediment.

"Bank erosion and channel migration are two physical process components of an active, wide channel that have been thwarted by the increased density of bank vegetation. The river channel has been progressively narrowing for several decades." (Conceptual Restoration Plan, Active Floodplain of the Rio Grande, San Acacia to San Marcial, Tetra Tech, Inc., 2004.)

In addition to the reduced capacity to move sediment, the Rio Grande has less sediment to move. Upstream storage facilities, erosion control in tributary drainages, and a bounty of wet years have all lessened the volume of sediment being transported. The result is a narrower, deeper river channel, and a system deprived of nutrients and dynamic change. What sediment there is constitutes a plumbing problem rather than a benefit in soil replenishment to the riparian system. Reservoir capacity is steadily being diminished; the MRGCD spends millions of dollars dredging silt from its works; streambed aggradation at San Marcial will eventually reproduce the flood that obliterated the town of the same name in 1929; and the Low Flow Conveyance Channel, originally constructed for making Rio Grande Compact deliveries in lean times, has been operational only half of the last forty-five years because it tends to fill with earth instead of flowing water.

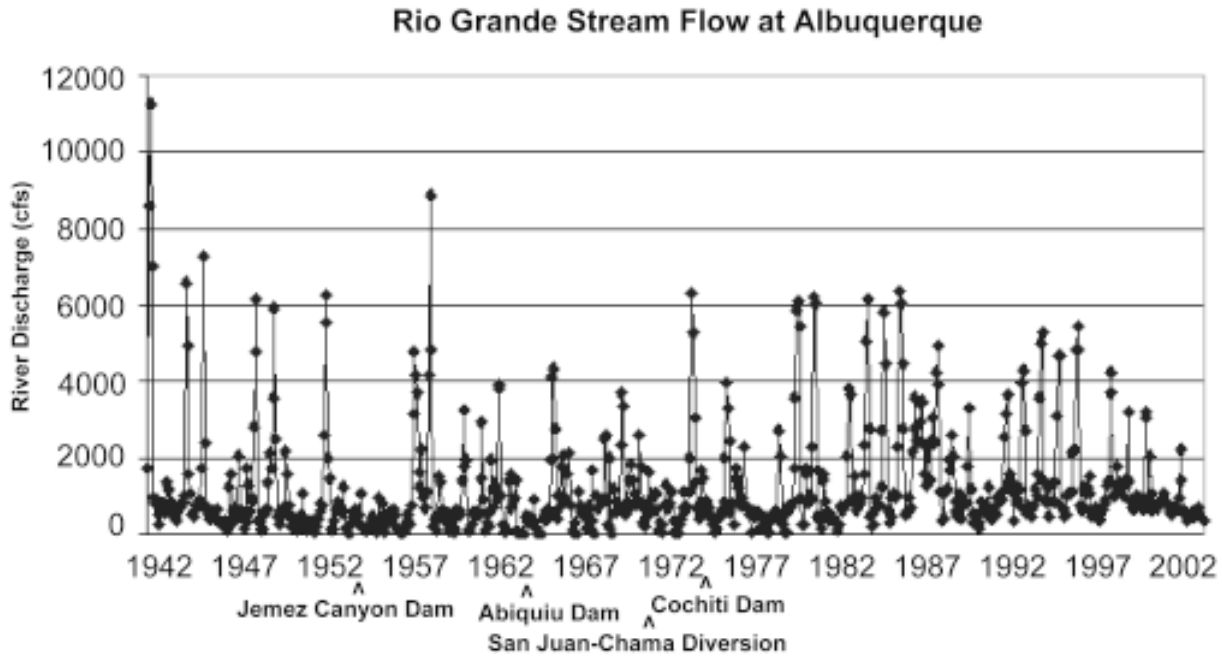


Figure 24. *The effect of dams and imported San Juan-Chama water on the variability of natural Rio Grande flows. Average monthy Rio Grande stream flow (cfs) at Albuquerque from March 1942 to September 2002. Marked along the x-axis are the approximate dates when Jemez Canyon Dam, Abiquiu Dam, and Cochiti Dam came online, as well as the start of the San Juan-Chama diversion.* (Hydrograph by Kim Eichhorst Mitchell)

"What is needed is a full suite of discharges on a sufficiently frequent basis to shape an alluvial river channel. The frequency and duration of flows that rework the active channel have been identified as the most important component in long-term maintenance of river function and form." (Conceptual Restoration Plan, San Acacia-to-San Marcial, Tetra Tech, Inc., 2004.)

"Some blanket recognition should be made that in spite of the noblest of efforts, a "natural" balance can never be achieved. If you are interested in a new ecological balance predicated on the core functions of hydrology and floodplain, then we should do our best, stand back, and let the system equalize. Restoring a more natural hydrograph and improving the ratio of grasses and wetlands won't provide a "recovered" ecosystem. A better one, to be sure, but one that will have its own particular host of problems." (Rob Leutheuser, Ret., Bureau of Reclamation Albuquerque Area Office, personal communication, 2004.)

Water management has also severely impacted the river corridor's natural patchwork of biological communities. The cottonwood bosque is now limited to a narrow strip between river levees, and the former mosaic of habitat types has been replaced with a continuous, linear, and static forest overrun with exotic species, choked with an accumulation of leaf litter and woody debris, and susceptible to catastrophic fire. According to the *Bosque Education Guide*, non-native pillbugs and woodlice are now the most abundant macro-invertebrates on the forest floor; between thirty-six and seventy-three percent of native fish species are gone from the Middle Rio Grande; native amphibians are declining along with the region's marshes; songbird populations are shrinking due to predation and lack of breeding habitat; and once-present species like jaguar, wolf, grizzly bear and mink have entirely disappeared (Morris et al., 2003). Although the notion is seldom expressed, these cumulative losses may be seen as an accompaniment of systemic desertification.

Of the quintessential services performed by the river, the interaction of surface flow and groundwater has perhaps the greatest significance for the Middle Rio Grande. A floodplain is a natural reservoir made up of riparian communities, wet meadows, marshes and ponds, all with their toes in a high water table. In years of ample moisture, the lowlands absorb the excess, while in periods of diminished yield, "high groundwater tables contribute seepage flow to the channel" (Tetra Tech, 2004). However, in much of the middle basin, the link between river and aquifer has been fundamentally undermined.

Figure 25. *Wetlands at Alameda.* (Photo courtesy of Ross Coleman, Hydra Aquatic, Inc.)

Since the early 1900s, wetlands in the middle valley have decreased by about ninety-three percent (Crawford et al., 1993). Much of that loss was a result of the drainage function of Middle Rio Grande Conservancy District, which was formed, in part, to reclaim severely waterlogged lands.

At an engineering level, the MRGCD's irrigation and drainage system is a surrogate for the regulated river. Water can be delivered to the farthest edges of the floodplain, imitating in a very controlled way natural overbank flows. A network of dirt-lined drains collects irrigation return flow and groundwater within ten feet of the land surface, and transports this salvaged water back to the river channel downstream, where it is again diverted and reused. This design resulted in an overall lowering of the valley water table by some five to six feet, and despite the reduction in natural wetlands, infiltration from flood-irrigated fields and leaking ditches has partially preserved the natural link between groundwater and surface water. According to the Bureau of Reclamation's 1997 Middle Rio Grande Water Assessment, fifty percent of the recharge to the Albuquerque basin is the result of such seepage (Bureau of Reclamation, 1997).

But there has been another infringement on the groundwater-surface water connection, and only recently have its full ramifications begun to be recognized. Urbanization is occurring at a rapid rate, both on the valley floor and along the depositional terraces and piedmont-slopes above the river. As these natural recharge zones are surrendered to development, less and less water percolates to the aquifer. Concurrently, an increasing number of municipal, commercial, domestic, and supplemental irrigation wells are tapping the water table at various levels. In the past, the unlined MRGCD conveyance system and the application of surface water to cropped acreage in the floodplain may have had a mollifying effect on groundwater drawdowns, but the inexorable subdivision of farmland and the drilling of new wells is beginning to outpace that offset.

> *"...MRGCD canals keep the shallow private domestic wells at a pretty constant level. It's a moderating system that doesn't really allow affects on the river to propagate to wells rapidly. You have canals on one side or both sides [of the river]... Those canals are intended to keep the river at a pretty constant stage. Well, they're not intended for that, but that's what they do, that's how they work." (Linda Logan, Office of the State Engineer Hydrology Bureau, testimony delivered on OSE File No. 4830, City of Albuquerque Drinking Water Project, February 26, 2003.)*

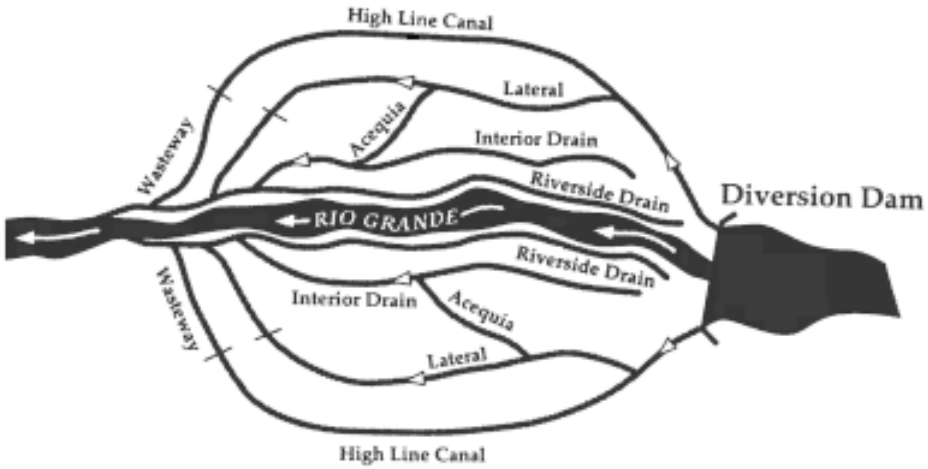


Figure 26. *Middle Rio Grande Conservancy District irrigation and drainage system.* (Graphic courtesy of MRGCD)

On the surface, this unacknowledged recharge dynamic is frequently interpreted as over-diversion by the MRGCD, for despite a steady decline in irrigated acreage, an excessive volume of water is required to meet annual demands. Diversions and return flows are gauged at several locations throughout the system, but there is currently no way to pinpoint precisely where the water is going. USGS studies of groundwater flow in the Albuquerque basin in the early 1990s revealed areas of serious decline in the water table, and in response, municipal resource managers devised a strategy to curtail pumping by switching to surface water. But the aquifer problem cannot be solved in anything short of decades because river flows (which will be substantially reduced by the municipal diversion of San Juan-Chama water) will still be drawn toward the lingering cones of depression. In fact, new USGS aquifer studies (Bexfield and Anderholm, 2002) verify that in some places, the path of groundwater has already been reversed: no longer does it move generally north to south in parallel with surface flow. Now it bleeds toward the most insistent wells, taking seepage from the river and the MRGCD system with it.

> *"Over the years, about 40 percent of [Albuquerque's] San Juan-Chama water has been made available to the farming community." (Albuquerque-Bernalillo County Water Utility Authority, "A Sustainable Water Supply for the Albuquerque Metropolitan Area," Albuquerque Journal supplement, February 13, 2005.)*

> *"The recent (1999 to 2002) water levels presented in this report indicate that beneath the Albuquerque metropolitan area, ground water on either side of the Rio Grande currently flows toward the major pumping centers from all directions…The contours of recent water levels also show that hydraulic gradients directed away from the river to both east and west are currently quite steep, especially as compared with predevelopment gradients." (Estimated Water-Level Declines in the Santa Fe Group Aquifer System in the Albuquerque Area, Bexfield and Anderholm, 2002.)*

Recreating some of the basin's wetlands, and consequently a healthier link between surface flow and groundwater is undoubtedly the most controversial of restoration stratagems because it raises the issue of increased evaporation. One of the original reasons for forming the Middle Rio Grande Conservancy District was the need to reduce evaporative losses in the middle basin. According to the agency's official plan, 50,000 acres had succumbed to alkali, salt grass and/or seepage by 1927. Based on very minimal data and using a coefficient of 76%, it was estimated that an average of 582,000 acre-feet of water was being evaporated or transpired annually above San Marcial (Burkholder, 1928).

Today's paucity of wetlands and weakened groundwater/surface water link are significant factors in the hydrologic system's debility.

> *"Broad values applying to wetlands include: 1) reduced flood intensities and frequencies, resulting in reduced damage and economic losses; 2) increased sediment retention resulting in less rapid sedimentation of reservoirs, irrigation systems and water works; 3) improved water quality benefiting fisheries, recreation, municipal, industrial and agricultural uses of downstream water; 4) aquifer recharge resulting in cheaper pumping costs and extended longevity of investments reliant on groundwater sources; 5) base flow augmentation benefiting fisheries, recreational and other dependent uses; and 6) other values related to natural heritage functions such as habitats for sensitive species, and scientific, educational, cultural and religious benefits." (Bill Zeedyk, Managing Roads for Wet Meadow Ecosystem Recovery, 1996.)*

The *Bosque Biological Management Plan's* authors considered wet meadow and marsh enhancement/extension the "most achievable recommendation in the plan," but not enough innovative work has been done along those lines. According to a USGS report on groundwater in the Middle Rio Grande basin (Bartolino and Cole, 2002), aquifer declines of more than 260 feet can initiate soil compaction and eventually surface subsidence. Decomposed granite and sandier soils that characterize the mesa uplands may stand some chance of being reconstituted, but clay soils, as are typical of much of the valley, tend to compress as they dry out, permanently preventing re-saturation. It may therefore be critical to preserve areas of the floodplain where groundwater-surface water connections have not been damaged, and where low-lying irrigated lands might be actively managed as wet meadows. It should be kept in mind that water seeping from the MRGCD conveyance system or from irrigated fields is not 'lost,' but percolates to shallow groundwater, or is picked up by conservancy drains and returned to the river.

> *"Because surface water and groundwater are connected in the Middle Rio Grande, seepage, transference losses, agricultural leaking, and groundwater recharge are not considered depletions. Similarly, groundwater pumping and increased transference efficiencies do not represent net gain in basin water supply." ("Habitat Restoration Plan," Middle Rio Grande Endangered Species Act Collaborative Program, 2003.)*

Figure 27. *Created wetlands near Polvadera, Socorro County*. (Photo courtesy of Ross Coleman, Hydra Aquatic, Inc.)

"The idea of 'wasteful' irrigation practices always comes up, but a concrete-lined ditch may actually evaporate more than a dirt ditch because of increased temperature. Remove the riparian vegetation and both water temperature and evaporation rates go up. Where there's vegetation, you get a surface film of dead air when you have a light breeze. Replace the vegetation with concrete, and a light breeze means increased evaporation. That's water that is 'lost.' With dirt ditches, whatever is leaking is not only recharging the groundwater, it's supporting riparian and wetland habitat all the way along. Farms offer a substitute environment, and in some cases, it's actually an enhanced environment. If you look where white-faced ibis hang out at certain times of the year, they're not on the river, they're in irrigated fields. The same is true of snowy egrets and sandhill cranes. So the floodplain is still providing some of those values via farming, and if you move the water to urban areas, wildlife is going to suffer, no question about it. If you want to talk about better efficiency and better operation of the irrigation delivery system, that's one thing. But if you're talking about taking water from the farm community and putting it back in the river, there are costs associated with that. You won't be 'restoring' the river by drying up its former floodplain." (Ross Coleman, wetland ecologist, Hydra Aquatic, Inc., personal communication, 2002.)

"Bosque and wetland habitats are relatively rare in the Middle Rio Grande today, and they are vitally important to many species. The ditches and drains (along with the agricultural fields they serve) have become default critical habitat for local and migrant birds, as well as for other forms of wildlife. For instance, biologists think the New Mexico meadow jumping mouse, which is on the state's threatened species list, is so far surviving the destruction of its natural wetland habitat because it is making use of mammate waterways instead. That argues for leaving such sanctuaries as 'wild' as possible." (University of New Mexico Biologist Lisa Ellis, personal communication, 2002.)

The decline of agricultural acreage and the prevailing fixation with 'saving' water by improving irrigation efficiency may constitute another sort of detriment to the hydrology of the Middle Rio Grande. Beyond providing a mechanism for shallow aquifer recharge, the makeshift floodplain plays an enormous part in maintaining water quality. Federal, state and tribal water quality standards do not regulate all the impurities that modern civilization introduces into the groundwater/surface water system, nor do they take into account the possible long-term effects of those additives on soil and biota.

Sediments are the principal reservoir of heavy metals and radionuclides in the environment. In the Rio Grande, river sediment generally contains much higher concentrations of heavy metal pollutants than the water does. The concentrations of chemicals adhered to sediments are important to the evaluation of water quality but are not often considered in traditional water quality studies. Contaminants often arrive in river sediments because of the erosion of waste disposal sites, or by the addition of contaminated discharges, and by atmospheric fallout. Large precipitation events wash sediments and pollutants into the river from surrounding lands through storm drains and intermittent tributaries, and there is concern about the contaminants in storm water, including those adhered to suspended sediments.

Rio Grande water quality varies primarily because of inflows of groundwater and surface water to the river. Water quality from Cochiti Reservoir to Isleta is affected by municipal wastewater discharges, storm water runoff, irrigation returns, and from tributary inflows. In the lower portion of the Middle Rio Grande,

irrigation return flows, uranium mining in the Rio Puerco watershed, and increased contributions of sediment, salts, and nutrients from the Rio Puerco and the Rio Salado all impact water quality. Throughout the basin, nutrient sources include atmospheric deposition; decaying organic material; weathering of rocks and minerals; human, animal, and domestic waste; phosphate detergents; fertilizers; septic-tank discharge; industrial waste; and urban runoff. Nitrate and nitrite are soluble forms of nitrogen commonly detected in both surface and groundwater of the Rio Grande. Volatile organic compounds including solvents and other toxic substances have been identified in groundwater in the Albuquerque area. Pesticide contamination occurs from agriculture, as well as from residential and commercial landscaping activities. Herbicides and DDT residues are often found in sediments, fish, and water, and although DDT is no longer used, the compound may still constitute a health risk when bioaccumulated from contaminated environments. It and other chemicals (for example, polychlorinated biphenal compounds, inorganic arsenic, and methylmercury) may thus pose health risks to frequent consumers of fish from the Rio Grande.

In short, water in the Rio Grande is subject to countless potential pollutants running off roads and parking lots, leaking from underground storage tanks, applied to lawns and crops, and flushed down household drains. It may also bear the legacies of weapons laboratories, military bases, and other industries that dispose of contaminants in permitted but perhaps cumulatively dangerous amounts. Finally, both river and groundwater are subject to millions upon millions of gallons of swill consigned to sewage plants and septic systems, calling into question the wisdom of using fresh water for waste disposal in the first place. Researchers have barely begun to ask how long any stream system can withstand such accumulations, or what mysterious allies might already be serving to absorb or transmute contaminants. The current ecosystem may, in part, be a product of pollution. Even a brief look into the field of phytoremediation suggests that two mainstays of the mid Rio Grande valley, cottonwoods and alfalfa, thrive on excess nitrates generated by, among other things, domestic septic systems. It might be practical to consider how potable the waters of the Rio Grande would be without the presence of bosque and hay fields.

That river processes are the backbone of ecosystem health in the Middle Rio Grande was certainly understood by the agency in charge of endangered species recovery. In designating critical habitat for the silvery minnow in 2002, biologists noted in the Federal Register:

> "This critical habitat designation takes into account the naturally dynamic nature of riverine systems and recognizes that floodplains (including riparian areas) are an integral part of the stream ecosystem. For example, riparian areas are seasonally flooded habitats (i.e., wetlands) that are major contributors to a variety of vital functions within the associated stream channel...They are responsible for energy and nutrient cycling, filtering runoff, absorbing and gradually releasing floodwater, recharging groundwater, maintaining streamflows, protecting stream banks from erosion, and providing shade and cover for fish and other aquatic species." (Federal Register, June 6, 2002.)

After ten years, the actions identified as necessary for river restoration and those deemed crucial for recovery of the silvery minnow are finally on a parallel course. There is basic agreement, however wary, that river health underwrites single-species health. If the floodplain is as unfettered as possible, if periodically there is sufficient flow to rearrange sandbars and their itinerant plant communities, and if a careful link is maintained between surface flow and groundwater, then the river once again becomes the curator of the tableau, and the steward of aquatic and riparian species.

In devising a more comprehensive road map for the future, resource managers would do well to return to the basic textbook on the Middle Rio Grande, the *Bosque Biological Management Plan*, which aspired to "determine conditions and recommend action that will sustain and enhance biological quality and ecosystem integrity of the Middle Rio Grande bosque, together with the river and floodplain that it integrates." Since 1993, many hundreds of copies of the manual have been distributed, and its tenets already inform the vast majority of restoration efforts in the central Rio Grande. The management plan's instructional, non-compulsory approach has contributed to broad public support for bosque and river revitalization initiatives, while more requisite attempts to safeguard the endangered silvery minnow have been bitterly divisive. In light of that fact alone, we would be wise to reaffirm ecology's underlying creed that river meanders, aquifers, trees, and fish are all threads in the same fabric, and that for better or worse, their fate is geographically, biologically, politically, and philosophically interlaced with our own.

Figure 28. *Rio Grande south of Albuquerque* (Photo courtesy of Janet Jarratt)

Part Three: Getting Real

"In recent decades we traded our mechanical model for a systems view, and glimpsed a partial answer: ignore the individual variables. Ecosystems are too complex for us to attend to all the parts, if we could count them, which we can't. Focus instead on the keystone processes that structure the systems and the variables will take care of themselves. The natural flow regime of the river, including periodic floods, is such a process. Fire preeminently is another. If you follow this idea where it leads you find yourself arguing strongly for 'adaptive management' notwithstanding that the concept has been more honored in the breach than the observance. Essentially, it calls for close monitoring of natural systems, restraint in placing stresses on the systems, and regular evaluation and revision of management behavior in response to monitoring feedback." (Bill deBuys, "Reflections on Environmentalism and the Future of the West," Quivira Coalition, 2003.)

"It's unfortunate that people don't really understand what we have to lose. You tell them the Middle Rio Grande is the best remaining example of a large river in the southwest and they're surprised. They haven't seen the lower Gila River or the lower Salt River, or the lower Colorado River, or the lower Rio Grande. It's sad how few recognize what is still here." (Ross Coleman, Hydra Aquatic, Inc., personal conversation, 2002.)

Since 1993, researchers, agency representatives, river restorationists and water managers in countless combinations and forums have been making recommendations about what must happen if ecological integrity is to be returned to the Middle Rio Grande. Interestingly enough, their thinking has served, again and again, to underline exactly what the authors of the *Bosque Biological Management Plan* suggested more than a decade ago: to effect real healing we must take into account hydrologic, morphologic, biologic, sociologic, legal, and administrative processes, as well as the river's capacity to adapt to change. That means cultivating an active connection between the river and the aquifer; providing variations in flow; and ensuring that the stream has sufficient lateral movement to transport sediment and distribute nutrients and biotic communities across its floodplain. In a populated river basin, though, it also means respecting the carrying capacity of the region, assuring the safety of its residents and property, guarding water quality, and guaranteeing that enough flow passes downstream to meet compact deliveries and vested water rights.

Priorities for ecosystem restoration fall into three general categories, two of which can be addressed through the existing recommendations of the *Bosque Biological Management Plan*. The first category is anchored to the reestablishment of a more naturally functioning river system through a mimicked hydrograph, attention to fluvial processes, and the interaction of groundwater and surface water. The second category addresses the need for integrated management along the Rio Grande and within its contributing watersheds, and involves data archiving, project monitoring, peer review, cooperative funding, and an active/adaptive approach to resource management. Finally, Recommendation 22 has been added to the management plan's original twenty-one, proposing the development of an outreach program to promote a comprehensive water conservation ethic, better communication with media and decision-makers, and ways to involve community in ecosystem restoration. These suggestions represent the wisdom of many thoughtful people, and the gold panned from thousands of hours of fieldwork and discussion. They reflect not only the difficult recent past, but also a more hopeful future.

(1) Promote natural system function by: mimicking the river's natural flow regime; allowing fluvial processes to occur to the greatest extent possible; and by protecting the dynamic of surface water/groundwater exchange

Mimic Historic Flows

The *Bosque Biological Management Plan's* primary recommendation was to mimic as closely as possible the Rio Grande's natural hydrograph. The one-hundred-sixty-mile reach that constitutes the Middle Rio Grande—from Cochiti Lake to the delta of Elephant Butte Reservoir—should be considered as a whole, and when there is an adequate water supply, the system should be actively managed to simulate historic flows. Currently, the Upper Rio Grande Water Operations effort and the ESA Collaborative Program have the wherewithal to address the timing of flows, and to institute policies that support system variability. One beneficial alteration might be timing Rio Grande Compact releases to coincide with environmental requirements. Compact water is presently moved through the system to Elephant Butte Reservoir during winter months, when riparian and aquatic species have little need for extra flows. The latitude to make such releases at other times of the year could provide water managers with additional flexibility.

Another means of introducing flexibility to the system is to rethink how water is stored. The release of Rio Grande credit water in exchange for upstream storage, as negotiated by Rio Grande Compact members in 2003, is a beginning. Collaboration on such transactions should be encouraged, with the goal of holding water in the most efficient place for the benefit of all. The concept of 'sponge storage' should also be explored by water managers the length of the river.

Already, real time flow data, progress toward a shared water accounting model, interagency teamwork and daily communication are the norm, necessitated by a mandate for protecting silvery minnows. That degree of cooperation needs to be extended to promoting overall system health.

Free the River Do Its Own Work

Although the river no longer has access to its entire floodplain, it should be encouraged to move naturally within the present or a modified levee system to improve channel dynamics, and to ensure that sediment is well distributed and nutrients made available to flow-dependent organisms. Restricting exotic vegetation like saltcedar and Russian olive along the river bank, and extracting buried jetty jacks wherever possible, would encourage formation of a wider, shallower river bed, and eventually, a mosaic of habitats, including backwater side channels, oxbows, seasonal wetlands, riparian forests of varying age, and grass meadows. Managed overbank flooding in such a setting would benefit the establishment and viability of native plant communities, stimulate the reproductive cycle of native fish, foster better water quality, offer alternatives to levee flood protection, and aid in bosque fire prevention.

> *"Water is water. It doesn't matter if you're talking about an ephemeral arroyo or an incised river, the principles of recovery are the same." (Bill Zeedyk, "Letting Nature Do the Work," Quivira Coalition, 2003.)*

Support High Flows

To accommodate higher river flows, 'choke points' (not just the symbolic San Marcial railroad bridge, but other types of river-crossings and important infrastructure directly adjacent to the river) could be re-

imagined with the goal of increasing system capacity. At the very least, both rural and urban communities should prohibit further development in the hundred-year floodplain. Conservation easements coupled with incentives for riparian rehabilitation (as are already being employed by the Socorro Save Our Bosque Task Force) could be implemented throughout the Middle Rio Grande. Since the present irrigation and drainage system serves as an extension of the river and of riparian habitat, the potential for using agricultural and undeveloped land for overflow is considerable. Flood flows might be directed to bleed-off areas, and allowed to infiltrate to the water table (Cliff Crawford, personal communication, 2003).

> *"We have to provide overbank flooding potential. If you don't have high flows on a regular basis, you can't maintain the river. Sandbars will become vegetated, armored, and channel capacity will be reduced. You have to have channel-forming discharges. You can recreate all the quality there used to be within the levees. It will be scaled down, but you can achieve it. The restoration projects that are in the works are steps in the right direction, but you've got to have higher flows. We need to educate people about the dangers of living right on the banks of the river. There are half-million dollar homes with absolutely no respect for potential floods, and they constrain the higher flows needed by the system." (Dick Kreiner, U.S. Army Corps of Engineers, personal communication, 2002.)*

> *"The sound-bite version of what needs to be done? Protect the existing levees but remove jetty jacks wherever you can. Level off the banks wherever possible to facilitate overbank flooding. Get peak flows back up, with a flood every three to four years. Look for places to return sediment to the system. Thin the riparian forest—remove non-natives and even dying cottonwoods—and open it up to native cover like saltgrass. It would also be good to identify potential wet meadow areas, and eventually do moist soil management up and down the valley." (Paul Tashjian, Hydrogeologist, U.S. Fish & Wildlife Service, personal communication, 2002.)*

Respect Ground-Surface Water Interactions

One tremendously important ingredient in returning the system to optimum health is the interaction between surface and groundwater. The two are widely acknowledged as one, but in fact, current policy does not support the combined administration of surface water and groundwater. No comprehensive inventory has been done of groundwater wells in the basin; the region is only beginning to suffer the consequences of aquifer depletion associated with pumping; and river flows will soon be altered substantially by the diversion and municipal consumption of San Juan-Chama water. There are unrelenting questions about how such puzzle pieces will affect the integrated groundwater/surface water system, and they must be answered with data, not with political rhetoric.

Since river flows can be undermined by groundwater depletion, an intensive grid of monitoring wells is needed to perceive the interface realistically. Overlapping cones of depression produced by adjacent wells of varying depths can interrupt and even capture local groundwater flow, so a true spatial and temporal picture of subsurface water in the basin will require a considerable number of monitoring sites up and down the valley, and across the entire floodplain.

Identify and Protect Lands With Priority Water Rights

Until a thorough monitoring program exists, prudence would dictate at least a temporary moratorium on new pumping permits, and an accounting of all permits previously issued under the State Engineer's

'dedication' policy. Without an up-to-date picture of what has been allocated, there is no way of knowing how paper guarantees stack up against the amount of 'wet water' the system can actually provide. The middle valley warrants a 'critical management area' designation *before* the situation reaches crisis proportions, not after the fact.

Though the subject of water rights has been carefully avoided in nearly every study, plan, and initiative concerning water in the state, some sort of blanket quantification of senior rights in the mid-Rio Grande basin is imperative. Identifying and honoring vested water rights is critically important here not simply because they are entitled to priority by law, but because they represent the residual floodplain, where the link between groundwater and surface water is still viable.

As suggested by one breakout group at New Mexico First's Town Hall on Water in November of 2004, a reasonable quantification of pre-1907 water rights still in use in the middle valley could be accomplished by referring to the 1917 Drainage Survey. Since the point of that survey was to ascertain the damage done to previously irrigable acreage by the aggrading river and rising water table, lands marked cultivated, seeped or alkali could be accorded basic historic status and cross-referenced with the MRGCD's 1926 Plane Table Survey field notes, which indicate the length of time a particular parcel had been under ditch and its then-current condition. Parcels that have since been developed or from which water rights have been severed could be subtracted from the total using county, MRGCD, and State Engineer geographic information system data. Priority could then be granted to those eligible lands still under irrigation. If nothing else, such an accounting would reveal how deeply in debt the region is with regard to promises vs. supply.

One practice which further jeopardizes both senior water rights and the overall water balance in the Middle Rio Grande is 'double-dipping.' As agricultural acreage is retired and the water rights are sold to serve development outside the floodplain, formerly irrigated lands are subdivided and domestic well permits are obtained for new housing on the retired parcels. Since the new domestic wells are entitled to pump the equivalent of what was transferred off as senior surface rights, and since the water being pumped comes from the shallow aquifer and thus from the river, the system is being tapped twice. Moreover, such 'permitted' rights to groundwater can physically impair unquantified senior surface rights because domestic wells are not regulated in the basin, and there is no means of limiting what is being pumped.

Proposals to facilitate water transfers from agricultural to urban uses through water markets and/or water banks assume economic development to be the 'highest and best use' of the resource. But what if restoring hydrologic integrity to the basin is the salient common good, not only for residents of the region, but also for the state as a whole? If part of the state's water management mission is to guard public welfare, then the ecosystem needs to be on a par with commercial enterprise. At present, development has no competition, and senior water right holders have no options. They cannot choose to sell or lease water to a riparian restoration program, or to sustain silvery minnows, or to benefit a stressed aquifer, or even to fund a drought reserve. They can only continue to irrigate, or succumb to increasing pressure to subdivide the land and transfer the water.

> *"If you want to have certainty in regional water planning, you have to have quantified rights…It's the avoidance of shortages that makes quantification important." (Stanley Pollack, Navajo Nation Water Rights Attorney, New Mexico Water Dialogue Statewide Meeting, June 11, 1998.)*

"We're concerned about Rio Rancho and Albuquerque. The more water they use, the less we have. Next week, Zia will pray for four days to bring rain to our area, to our state, to our nation, to our world. Spirit knows no boundaries." (Peter M. Pino, Tribal Administrator, Zia Pueblo, New Mexico Water Dialogue Statewide Meeting, January 13, 2000.)

Integrate Water Quality With Water Management

The other sleeping giant in the equation is water quality. What is *in* our water has generally been of less concern to resource managers than how much water there *is*, even though reason would suggest there is no quantity without quality. Quality, however, *is* a top concern of local water *users* (Brown, 2000.) The Rio Grande benefits from the presence of Native American communities that require water for religious practices and thus place strong emphasis on the quality of surface flows. Water quality standards adopted by a number of pueblos are more stringent than either federal or state requirements, and the region's municipal effluent is cleaner because of those regulations. Still, no standards now in place even begin to monitor all the compounds present in surface water, nor are we screening what accrues in sediment, in irrigated crops, or in the living tissue of inhabitants of the ecosystem. It is possible that the welter of chemicals used in industry and laboratories, road and automotive maintenance, food processing, household cleansers, cosmetics, and pharmaceuticals for the last hundred years have had a cumulative effect on ecosystem health. Water quality may indeed be a ticking time bomb.

Rio Grande water quality is affected by natural factors such as climate, geology, and soils; by temperature changes, sedimentation, runoff, erosion, organic loading and reduced oxygen content, changes in acidity and alkalinity (pH), pesticides, and an array of other toxic and hazardous substances and physical conditions. Ellis et al., 1993, reported that both point and nonpoint sources affect the water quality of the Rio Grande as it flows though New Mexico. Nonpoint sources include agricultural water diversion and irrigation, grazing, hydro modification, and urban development, whereas major point source discharges are from industry, wastewater treatment plants, feedlots, etc. Ephemeral and intermittent tributaries to the Rio Grande also affect water quality through loading, even though their contribution to river flow may be infrequent.

The ecology of fish communities was recently used to characterize water-quality conditions of the Rio Grande (Carter, 1997a and b, and Abeyta and Lusk, 2004). Carter reported that the relative percentages of introduced species and the dominance of omnivorous species in the Rio Grande near Isleta, New Mexico are indicative of biological stress. In all samples collected from the Rio Grande basin in New Mexico (Carter, 1997a), the occurrence of anomalies was less than two percent of the individuals, with the exception of the sample from the Rio Grande at Isleta, where the anomaly rate was fourteen percent. On the basis of such relative percentages, the fish community at Isleta appears to be the most impaired of all sites. The Middle Rio Grande water-quality assessment of silvery minnow habitats (written communication, Abeyta and Lusk, 2001), which sampled water, sediment, and fish in order to characterize water-quality conditions as they relate to established state and tribal water quality standards and to the health of individual fish and the ecological condition of their habitats, also suggests that fish health may be related to water quality.

In February of 2005, the New Mexico Environment Department Surface Water Quality Bureau announced an upcoming study in the Middle Rio Grande that will include a biological assessment, watershed protection, the development of total maximum daily loads to limit pollutants entering the Rio Grande, and a public outreach program. As yet, there is no monitoring or assessment schedule for the Middle Rio Grande, although the 2004-2006 303(d) Impairment Listings indicate problems with sedimentation, siltation, dissolved oxygen, pH, and fecal coliform in various reaches of the river or its tributaries. The New Mexico Environment

Department study will sample for dissolved solids, total suspended solids, and nutrients such as phosphorus, nitrate and ammonia; radiation; metals; organics such as pesticides and hydrocarbons; and *E. coli* and fecal coliform bacteria. It will include all components of the system: biological (fish and insect assemblages), chemical (pH, temperature, dissolved oxygen, metals, organics, etc.), and physical (channel morphology and substrate composition). It is to be hoped that these studies will complement U.S. Fish & Wildlife Service's research on fish health, and will advance our understanding of the effects of water quality on *all* constituents of the Rio Grande basin ecosystem.

Extend 'Restoration' to the Watershed

River and habitat restoration tends to focus on the main riparian corridor, leaving the mitigation of conditions in the uplands to land-based agencies. The result is that the direct relationship between upper watershed health and flow downstream has not been well communicated to legislative or funding bodies, or even to resource managers and agencies themselves.

Concern for healthy river function ought not be limited to the mainstem Rio Grande. Recommendation twenty-one of the *Bosque Biological Management Plan* acknowledges that protecting and enhancing ecosystem integrity will ultimately require "integrated management of all the watersheds that collectively make up the Rio Grande drainage." Restoration to promote more natural flow regimes and channel dynamics along perennial and ephemeral tributaries to the Rio Grande could also be undertaken. Dense stands of woody vegetation including saltcedar, Russian olive, Siberian elm, piñon/juniper, and ponderosa pine could be thinned and managed to restore the grassland component throughout the drainage basin, and land use policy re-examined to effect holistic watershed protection, with no new disturbances allowed in riparian or groundwater recharge zones.

> *"Hillslope, stream and aquifer are an integrated unit, linked through the movement of water. Those linkages are influenced by geologic composition, and we can predict the way water will move through a catchment, based on the geologic setting in which the catchment occurs. The direct implications are that this influences not only surface water, but also groundwater flow. There are also issues of erosion—so you've tied in land use, and potential differences in water quality. The influence of cattle grazing, for instance, will vary depending upon the underlying geology. We need to integrate our understanding of these multiple components if we want to produce positive changes within a stream." (Maury Valett, University of New Mexico Department of Biology; personal communication, 1997.)*

(2) Pursue integrated, active/adaptive resource management

Share Data

The *Bosque Biological Management Plan* proposed a coordinated program to monitor biological quality and ecosystem integrity. Specifically, the recommendation called for standardized monitoring at designated points along the Middle Rio Grande of (1) changes in river morphology; (2) sediment transport and its influence on aquatic and riparian communities; (3) changes in ground and surface water levels, soil moisture, salinity, and relationship to river flows; (4) nutrient cycling; (5) changes in structure and composition of plant

and animal communities in the river corridor; (6) cottonwood and willow recruitment and establishment; (7) changes in distribution of species highly sensitive to disturbance; (8) changes in introduced species; (9) changes in seasonal and meteorological conditions in diverse forest habitats; (10) frequency and effects of fires; (11) effects of livestock grazing; and (12) the extent and effects of recreational use. Currently, the Bosque Initiative/BIG, the Bosque Ecosystem Monitoring Program, and the ESA Collaborative Program have pieces of this role, but as yet, there is no "centralized monitoring clearinghouse."

Aside from the need for a repository for collective data, what is learned must be *applied*. Ongoing monitoring and research constitutes grist for modelers of the system, and modelers should be willing to constantly incorporate new information. In turn, the improved model suggests where further data is needed and more research must be done. This reciprocal adaptation process ought to form the basis for policy decisions and active management.

> *"Present efforts to solve problems in the Rio Grande riparian area suffer for three reasons: There is no adequate, unbiased peer review; no independent external advisory panel; and no clear set of evaluation criteria established to assess the work even though some of that could easily come right out of the Bosque Biological Management Plan." (Cliff Dahm, personal communication, 2002.)*

Minimize Rivalry and Isolated Initiatives

Funding for restoration in the Middle Rio Grande needs to be approached in a more holistic way. Competition for private, state, and federal dollars is fierce, even among departments of the same agency, and decisions need to be made with the overall ecosystem in mind. If projects are financed piecemeal, crucial work begun in one cycle may come up short in the next.

Agencies and their consultants still compartmentalize projects, impeding the exchange of information and often duplicating effort. Examples that come to mind are the different-yet-overlapping sets of river reach delineation done for similar clients by separate environmental contractors, and various study proposals that fail to make use of existing data and/or monitoring programs. Wherever possible, interfacing of multiple projects should be accommodated.

Triage and Fund Ecosystem Basics

Thanks to fellowship among members of the Bosque Improvement Group and oversight by the Bosque Initiative, many of the projects funded in the past decade were understood in an ecosystem context, and to some extent, even a watershed context. As participants themselves, those who assigned monies to various proposals grasped the bigger picture, and the tendency has been to aid each other in furthering overall goals. With the shift to the Endangered Species Act Collaborative as the main funding mechanism for water-related projects the middle basin, the question arises whether single-species matters will dictate which programs flourish and which wane, perhaps to the detriment of the total restoration effort.

Considerable resources are being brought to the basin through the political process, and those resources need to be applied to solve overarching problems, not chronic symptoms. A single sieving process for all proposed ecosystem and hydrologic restoration work would certainly help elicit more mileage from each project and each allocation. If such orchestration can be achieved in the Kissimmee River Basin, it can be achieved in the Middle Rio Grande as well.

What must also be acknowledged is that as the nation confronts unprecedented mounting debt, federal dollars for environmental repair may dwindle and perhaps cease entirely. While funds are still available, they might best be spent on the most essential tasks—returning a modicum of self-sufficiency to the river and creating local partnerships to ensure continued attention to the ecosystem—rather than creating bloated infrastructure that will leave the Middle Rio Grande in limbo when fiscal resources dry up.

> *"The ESA Collaborative Program got $11.2 million in 2002, and around $12.7 million in 2003. Those are significant amounts of money. The National Science Foundation, which is recognized to be a very efficient use of taxpayer money, spends about three or four percent of its operating budget on project management. If you have a program that is generating $11 to $12 million dollars, dedicating three or four percent to program management makes good sense; dedicating ten percent to management does not." (Cliff Dahm, University of New Mexico Department of Biology, personal communication, 2003).*

> *"Your agency sends you to a meeting to protect and defend your constituents' rights and privileges. You're there to minimize any potential negative impact. If you come together for that reason, the scope and the feeling of that meeting is one thing. But if you're sent there to identify and maximize the benefits to something—to figure the first order, and second order, and third order of effect, and to optimize the maximum benefit we can all get from this, the tenor of the meeting is going to be completely different. What you'll have at the end of the day is a 'lowest common denominator' of alternatives. You eliminate the options that are too hard, and instead identify some creative things that need to happen and can be accomplished. (Ret. Col. Steve Wagner, U.S. Army Corps of Engineers, personal communication, 2002)*

Learn the Lessons of the Previous Decade

There have been more than enough plans, initiatives, task forces, forums, consortiums, work groups and 'ad hocs' that focused collective attention on what to do to ensure the health of the Middle Rio Grande ecosystem. Not to say that such an extensive examination was unnecessary, for in the vivid words of the region's first Bosque Coordinator, Jeff Whitney, "The more times you run over a dead cat, the flatter it gets." It's taken a decade to flatten this cat, and what we've found through countless studies, projects, and convocations is that the conclusions of the *Bosque Biological Management Plan* are difficult to refute. The authors of that plan saw a need for some sort of council to oversee riparian restoration in the basin. While no official authority was ever coined to fill this need, successful forums *have* evolved, and it is in the region's best interest to retain and to integrate the foremost of these. Since endangered species demands can best be addressed within the context of whole-system restoration and the reverse is not true, some hybrid that includes the Bosque Initiative/BIG, the Upper Rio Grande Water Operations modeling effort, and the ESA Collaborative Program would be a more effective umbrella than the Collaborative Program alone. In light of numerous mutual projects and common key members, these partnerships already constitute the makings of a strong platform for effecting ecosystem recovery and holistic water management in the mid-Rio Grande.

Another thing the basin can do without is more litigation that sidetracks the financial resources of dozens of strapped agencies and all but freezes the desire to cooperate. The forest of legal paper resulting from past hostilities suggests that if our calisthenics had been directed at implementing the *Bosque Biological Management Plan's* twenty-one recommendations, most of the crucial work would already be done. Undeniably, lawsuits have served as a catalyst for raising public consciousness and for forcing reluctant players

to the table, but nothing remains a catalyst indefinitely. If anything good can be said of litigation, it is that in comparison, collaboration is a picnic. True collaboration engenders public will, and advocates for the river have been engaged in exactly that for over a decade. Most residents of the Middle Rio Grande have at least heard the word 'ecosystem.' They also have an inkling that water is an issue here, that our most worrisome challenge is having enough of it, and that in determining how it will be used, humankind is not the only constituent that counts. Since 1993, the Middle Rio Grande has come many, many miles toward a collective creed concerning ecosystem health.

Put 'Ecosystem' First

If the experts know how to achieve restoration goals, and there is at least a public inclination to support those efforts, what is lacking? Above all, it is legal and administrative incentive. The booklet *"Taking Charge of Our Water Destiny: A Water Management Policy Guide for New Mexico in the 21st Century,"* (Belin et al., 2002) contains a section on the ABC's of existing state water law. It is a sad fact that the list of governing policies includes not one word about watersheds, ecosystems, riperian environment or riverine corridors. Because of that wholesale omission, we must now reassign a portion of our most precious resource to a heretofore-unacknowledged player, the stream itself. The disregard of natural systems first came to national attention in the 1970s and is only now playing out on the state and local level: how can a critical new wedge be equitably shaved from a finite pie that has already been split up and handed out?

> *"Designating water for ecological support is no more radical a notion than suggesting that the bricks comprising a building's foundation not be pulled out and used to construct the fourth or fifth story. Economic growth that destroys ecological supports systems is neither sustainable nor truly progress." (Rivers for Life, Postel and Richter, page 81.)*

What we have yet to accept is that the 'ecosystem' is not some independent entity beyond ourselves, but the sum total of connections that sculpt our local existence: a high desert setting; the patchwork of faults and sediments that underlie the surface; an undervalued, over-allocated, exceedingly regulated river and its essential pantry of groundwater bled by countless wells; a mélange of microbes and chemicals that can bolster or destroy fundamental processes; and an ever-changing balance of predators to prey.

It is no coincidence that the linguistic root of both 'ecosystem' and 'economy' is a word that means HOME. What we consider to be our habitat has far-reaching consequences, and taking care of it is in *everybody's* best interest. There is no such thing as 'turf' and no elite player—not the feds; not the OSE, the ISC, or the MRGCD; not the pueblos or the *acequias*; not the environmentalists, the developers, or the municipalities. All face the same challenge: how to reconcile climate change, unprecedented growth, prior rights, compact compliance, ESA mandates, the hidden price tag of aquifer mining, and our overriding addiction to excess.

Suppositions about where the water will come from for future generations need reexamining, along with old concepts of highest and best use. Physical repair to the river-dependant ecosystem must be accompanied by changes in policy and philosophy. Buzzwords to which we have become inured—*sustainable, delayed effects, conjunctive management*—must begin to carry literal meaning. Water *is* the limit here, and we have too long been sheltered from that reality by a combination of fortunate timing (life during a wet period), human ingenuity (we have moved water through mountains!), and bureaucratic wile (water = paper). But change is inescapable, and the connections we formerly disregarded must finally be affirmed. The fact is that climate swings between extremes, river flow swings between extremes, populations swing between

extremes, and humans do not command these processes. We can, however, realign our habits with the shifting constraints of place instead of presuming to discount them.

Balancing Current and Future Demands on Freshwater Supply

1) Promotion of an "environmental water reserve" to ensure that ecosystems receive the quantity, quality, and timing of flows needed to support their ecological functions and their services to society. Legal recognition of surface and renewable groundwaters as a single coupled resource.

2) Improved monitoring, assessment, and forecasting of water quantity and quality for allocating water resources among competitive needs.

3) Protection of critical habitats such as groundwater recharge zones and watersheds.

4) A more realistic valuation of water and freshwater ecosystem services.

5) Stronger economic incentives for efficient water use in all sectors of the economy.

6) Continued improvement in eliminating point and nonpoint sources of pollution.

7) A well-coordinated national plan for managing diverse and growing pressures on freshwater systems and for establishing goals and research priorities for crosscutting water issues.

(Water In A Changing World, Jackson et al., 2001.)

"Until we commit to trying solutions that are more holistic in nature; until there's a willingness to work cooperatively to facilitate this; and until there's a commitment to the very best science driving the process, I think we're not going to make a lot of progress." (Cliff Dahm, University of New Mexico Department of Biology, personal communication, 2002.)

"One of the main things the Bosque Biological Management Plan did—and continues to do now—is give professionals the reasons for restoration. It's a document that represents a lot of diverse backgrounds and thought processes, and it was the start of the consensus work that we're engaged in now. There's a lot being done. We've pulled big dollars into a poor state. Now we just have to spend them in a holistic way. We are becoming better acquainted with cooperative efforts, and we're stepping away from the 'my way or the highway' mentality to acknowledge the value of partners." (Gina Dello Russo, Refuge Ecologist, Bosque del Apache National Wildlife Refuge, personal communication, 2002.)

3) Build consensus and partnership through active outreach

Public support for restoring and maintaining ecosystem integrity is gained from awareness and involvement. Education and outreach are vital components for bolstering community concern and commitment.

Promote A Strong Water Conservation Ethic

A realistic and aggregate picture of the region's water needs, beginning with our obligation to the physical system, must underpin efforts to conserve. Every use sector must acknowledge the serious deficit in the regional water budget, and find ways to trim usage with the express understanding that any conserved water will not simply be 'freed up' for more growth.

(a) *Redouble Urban Water Conservation Efforts*

In 2004, the state legislature transferred Albuquerque's water utility to a new joint authority controlled by three Bernalillo County commissioners, three Albuquerque city councilors, and the city's mayor. The Albuquerque-Bernalillo County Water Utility Authority now oversees Albuquerque's former water utility, including its programs, operations and water rights. Currently there are discrepancies between water conservation standards to which city residents are subject and the absence of such standards in unincorporated areas overseen by the county. It remains to be seen how the new Authority will address some of the issues discussed below.

Albuquerque's city council adopted a Long-Range Water Conservation Strategy in 1995, with the goal of achieving a 30% reduction in water use to bring daily per capita consumption to 175 gallons by 2004. The document acknowledged that conservation could "extend the city's supply at a fraction of the cost of other alternatives" and that "raising the price of water is probably the most effective method for reducing usage." Since that time, the city has succeeded in reducing its water consumption from 252 gallons per person per day to about 190, primarily through public education, water audits, and incentive programs for converting turf to xeriscape and installing low water use toilets, washing machines, and dishwashers. Modest water rate increases and water waste surcharges have been imposed, although the cost of water is still low compared to many other southwestern cities. Citations are issued and fines imposed for water waste; restaurants serve water to customers only upon request; lodging establishments encourage the reuse of sheets and towels by those staying more than one night; and builders have to adhere to water conservation guidelines for turf and toilets.

Despite these efforts, Albuquerque's per capita water use continues to hover around 190 gallons per person per day (gpppd), while per capita usage in comparable southwestern cities such as Tucson and El Paso is in the 145 to 160 gpppd range. Under severe drought restrictions in 2003, the city of Santa Fe achieved a per capita use of 118 gpppd. Albuquerque's website (*www.cabq.gov*) says the goal of 175 gallons per person per day has already been reached, but "unaccounted for" water is not included in that reckoning. Eleven percent (about four billion gallons of water each year) goes unaccounted for in the Albuquerque municipal system (*Albuquerque Journal*, July 21, 2004).

Also skewing the reported figure is groundwater being pumped from non-municipal wells, (*e.g*. those owned by entities such as Kirtland Air Force Base, the University of New Mexico, and New Mexico Utilities, Inc.) and from domestic wells that serve households hooked to the municipal sewer system. The city earns return flow credits for half of this water since it is discharged to the Rio Grande as treated effluent; however, the non-municipal gallons pumped are not included in the city's overall water use figures.

Staffing and budgetary resources for Albuquerque's Water Conservation Program have flat-lined in recent years, even as the number of new municipal constituents served by the city steadily increases. (According to a KOAT-TV news report in February of 2005, some 7,000 new homes were built in 2004, continuing a trend of record-setting development in the last five years.) The philosophy that cities are entitled to grow at the expense of other water use sectors, including the environment, is prevalent among governments of the region, yet the *public*, as reflected in both the Middle Rio Grande Regional Water Planning process and in surveys such as the one conducted by the University of New Mexico's Institute for Public Policy, does not seem convinced that unrestricted development is wise or inevitable. Instead, residents prefer that the basin's water be used primarily for (1) drinking and bathing, (2) the river and the bosque, and (3) agriculture (Brown et al., 2000).

Meanwhile, concern for the condition of the middle basin aquifer increases (USGS, 2003). As hydrologist Doug McAda notes in the *Albuquerque Tribune* of February 3, 2003, "The aquifer surrounding the Rio Grande is recharged almost solely by the river, rather than getting additional water from mountain flows that trickle down through the ground." Given such clear counsel, the Albuquerque/Bernalillo County Water Utility Authority may need to reexamine its inherited Water Management Strategy, the proposed use of San Juan-Chama water, and municipal responsibility to the river. One concession that could be made to the ecosystem would be to tithe a percentage of all water acquired for urban development to support the region's hydrologic health.

Eventually, all Middle Rio Grande municipalities will have to commit to more intensive water conservation to prevent further aquifer drawdown. Opportunities for saving water are many. Municipalities might adopt water budgets consistent with the regional budget, require annual audits, and establish water rates that reflect the *scarcity* of the resource—the more you use, the more you pay. They could also institute an educational campaign to promote watershed awareness, and to solicit creative ways to 'reduce, recycle, retrofit and recharge.' A rebate program to upgrade inefficient urban and suburban irrigation systems could be undertaken; water-thrifty native grasses and ground covers could be promoted instead of non-native ornamental turf in residences, parks, school yards and recreational facilities; recycled water could be employed to irrigate all public turf; and playing fields and open space could be designed to double as catchment areas and natural filters for storm runoff. Such 'urban watershed' practices would allow precipitation to percolate instead of being swept (along with trash and pollutants) down nonporous channels to the river. Above all, municipalities could choose to educate their constituents about the realities and responsibilities of living in a desert.

> *"Water consumption runs fifty-six gallons per person per day at our local water co-op. Surveys on other local water systems indicate they all tend to run under sixty gpppd. You do that with a parabolic rate scale. Your basic needs are met for about $35 a month, but if you start using over 4,000 gallons a month per household, your rate increases parabolically. If you want to irrigate half an acre of grass, it'll cost you $600 a month. It's a simple equation, very egalitarian. It's beyond the reach of the political quagmire. But a municipal water conservation department responds to a department head that responds to a mayor that responds to the polls. It will take a very, very brave leader to say, 'We're going to change the way we pay for water, and here are the new rules.'" (Ross Coleman, wetland ecologist, Hydra Aquatic, Inc., personal communication, 2002.)*

> *"There needs to be a courageous and explicit admission that the limited and finite supply of water cannot support infinite growth. If this is not acknowledged and planned for, and growth overshoots the water supply, resultant economic*

and social conditions will be so untenable that there would be an organic emigration from the area. The burden would not be equally shared among the classes." (Rob Leutheuser, U.S. Bureau of Reclamation, and coauthor Bosque Biological Management Plan, written communication, 2004.)

(b) *Expand Agricultural Water Conservation*

In the agricultural sector, efficiency is gradually improving throughout the Middle Rio Grande Conservancy District. Flow meters are being installed on all diversion and delivery canals; dams and canals are being fitted with automatic control gates; troublesome segments of the conveyance system are judiciously being lined to reduce seepage and/or to facilitate flow. According to the MRGCD website (January 2005), these improvements, funded by a combination of federal and state agencies since 1996, have so far reduced agricultural diversions by 47%. Future conservation efforts include an engineering evaluation of the entire system; construction of a siphon at La Joya; increasing the capacity of crossing structures at canals and drains; installing weather stations to provide up-to-date information on localized precipitation and soil moisture; and controlling non-native phreatophytes both in the bosque and along the conveyance system. The MRGCD also has a pilot project underway to assess the use of goats to keep regrowth of saltcedar and other exotics to a minimum in restored areas.

Irrigation scheduling and rotation are being implemented in the MRGCD's Belen Division, but the program has yet to be extended to the Cochiti, Albuquerque and Socorro Divisions. To prove beneficial, rotation needs to be consistently and fairly applied among all irrigators, throughout the MRGCD. At the same time, sufficient flexibility should be built into the schedule to accommodate different crop timetables and extenuating circumstances. In tandem with system-wide scheduling, there is a need for comprehensive and ongoing training for ditch riders, annual orientation meetings with irrigators, and some means of educating new landowners regarding irrigation rules and etiquette. Overall, better communication is critical to agricultural water conservation efforts.

Incentives for on-farm efficiency could also be pursued by the MRGCD, with water savings most likely realized on smaller parcels of land that are not currently eligible for cost sharing help from federal programs. In addition to or perhaps in conjunction with on-farm efficiency improvements, a forbearance option, whereby individual landowners could forego irrigating and lease unused water to help meet other needs, could also be a valuable conservation tool, provided that vested water rights are reasonably quantified and protected in the middle valley. The forbearance concept as applied to an entire ditch may not be feasible, however, because it assumes that water rights are the property of the delivering agent and not of individual landowners. Participation in a forbearance or fallowing program should necessarily require the installation of a headgate meter, and the continued obligation to pay an MRGCD water service charge.

In initiating any or all of the foregoing measures, the MRGCD's distinctive role in the region's hydrology should be recognized and care taken not to further undermine existing groundwater/surface water interaction with conservation measures aimed simply at bolstering surface flow.

"We have options for reducing undesirable depletions (reservoir evaporation and riparian evapotranspiration by non-native species) and stretching our supplies (conservation, realistic growth, irrigation efficiency). Two requirements are primary: learn to share, and live within our means." (Peggy Johnson, "Water In the Desert," New Mexico Earth Matters, Vol. 1, No. 1, January, 2001.)

Engage the Public and Solicit Community Action

The possibilities for involving communities and citizens in ecosystem restoration have barely begun to be explored. What stands out above all in this long and incomplete review of the past decade is that wonderfully unforeseen combinations of agency folk, nonprofit organizations, and altruistic individuals have come together to make hundreds of on-the-ground projects happen. While the official debate wore on about who should be in charge and where the effort should be focused, those who simply cared about the Middle Rio Grande ecosystem were steadfastly inventing ways to accomplish the work. That resourcefulness is the human equivalent of ecosystem diversity and ingenuity, and so it prompts this single addition to the original twenty-one recommendations of the *Bosque Biological Management Plan*:

> ***RECOMMENDATION 22 - Develop outreach initiatives through public education programs and events, and community participation activities and projects, to broaden public understanding of and generate more active interest in bosque restoration and river ecosystem management in the Middle Rio Grande.***

Need: Those already at work on solutions to the myriad challenges facing the Rio Grande consistently articulate that public education and outreach are essential to their efforts. A general public that is well-informed and more involved will support ecosystem restoration and management, assuring better stewardship of the Middle Rio Grande. Outreach priorities include programs for community education and involvement, promotion of a well-versed local media, and the establishment of an ongoing dialogue between researchers, resource managers, community leaders and opinion makers. The need to interface sound science and policy decisions is a high priority.

Description of Recommendation: The development of creative educational resources and outreach initiatives that broaden appreciation and knowledge of the Rio Grande will help to assure that the river and bosque are viewed as integral to the Middle Rio Grande region and its quality of life. This recommendation encourages the continued development, distribution, and implementation of informational tools and activities that promote an understanding of the ecosystem concept. Outreach tools and activities may be direct and/or indirect products of projects implemented under any of the other recommendations of the *Bosque Biological Management Plan.*

Opportunities and constraints: New forums are not necessarily required for the development of informational tools and programs, though collaborative efforts could be undertaken to work with local media and on policy initiatives. Numerous formal and informal groups and comprehensive educational efforts already exist. Some of these include, but are not limited to:

- Bosque Ecosystem Monitoring Project (BEMP)
- Bosque Hydrology Group
- City of Albuquerque
    - Open Space Division
    - Biological Park
- Rio Grande Restoration
- Rio Grande Nature Center
- Friends of the Rio Grande Nature Center State Park

    - Rio Grande Ecology Institute
    - Bosque Education Guide
- Middle Rio Grande Endangered Species Collaborative Program
- Friends of Rio Rancho Open Space
- National Hispanic Cultural Center of New Mexico
    - Jardines del Bosque Research Station
- New Mexico Museum of Natural History and Science
    - Student Ecology Research Project
- Socorro Save Our Bosque Task Force
- Tree New Mexico, Inc.
- U.S. Army Corps of Engineer's Bosque Revitalization Project

Implementation Considerations: Possibilities for education and outreach include workshops and environmental education programs; restoration site visits; displays and exhibits; publications, videos and web sites; training courses; media briefings, etc. Whenever possible, communication and collaboration is recommended to make the best use of already existing resources and initiatives. Media education and outreach can be accomplished through both local and regional efforts. The interface of sound science and policy through regular communication with political and community leaders is of utmost importance.

Action: During the past ten years, the Bosque Initiative/BIG has seeded a multitude of community-based projects, implemented a broad range of the *Bosque Biological Management Plan's* 21 recommendations and, at the same time, created public awareness about bosque and river conditions, inspiring participation in research, monitoring, and restoration efforts. Examples of programs representative of the creative potential of education and outreach include:

- The Bosque Ecosystem Monitoring Program involves teachers and students from both public and private schools in hands-on data gathering activities that have greatly contributed to scientific knowledge about the bosque and the river ecosystem. Because monitoring is such an essential component of science, the program is a model that could be duplicated in other communities along the river in order to expand and broaden vital data collection.

- The Bosque Restoration Demonstration Project, a joint effort of the City of Albuquerque Open Space Division, the local nonprofit Rio Grande Restoration, and the Middle Rio Grande Conservancy District, was conceived to generate greater community awareness about the bosque and the Rio Grande through both on-site educational programs and public participation in restoration activities. The site was designed to dramatically portray the contrast between a restored bosque mosaic and the current bosque inundated with invasive species. Tours were conducted for school and community groups as well as political leaders. Other community-based restoration projects underway in Socorro County, Los Lunas, Rio Rancho, and at the Pueblo of Sandia offer examples of joint efforts and creative local alliances among governmental and non-governmental entities.

- The Bosque Education Guide's K-12 curriculum for teachers and students presents historic, scientific, and cultural dimensions of the bosque and the river through creative play and on-site projects. It is a multifaceted resource that could also be useful for media outreach and educational dialogue with public officials.

- The Bosque Landscape Alteration initiative, which grew out of the individual efforts of Sterling Grogan of the MRGCD and Cliff Crawford of the University of New Mexico, has the potential to engage both the public and policy makers. The proposal seeks to recreate a more natural riparian

mosaic, reduce the fuel load in the bosque, and save water presently transpired by exotic vegetation. Bosque fires and water salvage are galvanizing issues that can be used to focus attention on the greater challenge of ecosystem husbandry. They can also provide an opportunity for grounding strategy and policy in accurate science, which must become the norm if viable restoration is to be accomplished.

A media strategy that includes briefing sessions with reporters and editorial boards, interviews for television and radio talk shows, and periodic feature stories about community-based activities and scientific research would be an invaluable outreach endeavor. In developing such a strategy, the capability to be both proactive and reactive is equally important; supplying information to the public about ecosystem-related activities and scientific findings should receive as much emphasis as responding to bosque fires or drought.

How to foster a more proactive interface between sound science and administrative policy needs to be a focus of discussion and collaboration among technical groups and university researchers. The Bosque Hydrology Group might provide the impetus for this effort.

Monitoring and Research: As noted above regarding the Bosque Ecosystem Monitoring Program, and more fully in an earlier section of this chapter, making the current findings of monitoring and research available to decision makers is critical to achieving ecosystem restoration and active resource management. The *Bosque Biological Management Plan* identified the need for establishing a clearinghouse "for receiving, managing, transmitting, and storing management-related information." Such an archival entity would help assure the best use of data and resources, and would serve to facilitate greater consistency, communication, and coordination among existing efforts. The Middle Rio Grande Bosque Initiative website provides access to many publications and programs through its "Resources" and "Links" buttons. Every project funded by the Bosque Initiative is required to have an annual progress and/or final report, and these are being added to the archive. Cross-links to other programs involving river and ecosystem management (the Middle Rio Grande Endangered Species Act Collaborative Program, the Rocky Mountain Research Program, etc.,) may be the most effective way to establish a wide-ranging, updateable, publicly accessible collection of research materials and data.

Agencies with Potential Contributions to the Middle Rio Grande Ecosystem: All agencies and entities listed in, but not limited to, Appendix IV of the Middle Rio Grande Ecosystem: Bosque Biological Management Plan (Crawford, et al., 1993).

To carry the ecosystem approach to its appropriate conclusion, public consciousness needs to inform agencies and elected officials regarding the ecologic welfare of the Middle Rio Grande. It is up to those who study and model and participate and plan to impart what they learn, and thus to hold governments accountable for making truly community-minded decisions. In the process, we may finally come to comprehend ourselves as integral parts of the whole.

> *"We're on the verge of reclaiming this ecosystem. We've built the will to do it, and the understanding to do it, and now we're really ready to begin." (Paul Tashjian, Hydrogeologist, U.S. Fish & Wildlife Service, personal communication, 2003.)*

Glossary

Abiotic—The chemical and physical aspects of an organism's environment, in contrast to its biological parameters. Abiotic elements might include local hydrology, nutrient availability, seasonal temperature, wildfire, and human engineering or policy. An ecosystem evolves from both biotic and abiotic processes, and from the interactions between them.

Acequia—A community irrigation ditch, cooperatively owned and maintained by the people who use it. Beyond providing for the physical transport of water, *acequias* are political subdivisions of the state and represent the earliest form of democratic government in North America. Approximately one thousand are still in operation in New Mexico, and others have been consolidated into extensive conveyance systems like that of the Middle Rio Grande Conservancy District. Next to the water rights of Native Americans, *acequia* rights to the use of water are the oldest in the state.

Acre-foot—The amount of water (equivalent to 325,851 gallons) required to cover an acre of land to a depth of one foot.

Active management / adaptive management— A systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. (Says UNM ecologist Cliff Dahm: "It basically means stop digging if you find yourself in a hole and you want to get out.")

Adjudication—A court determination of the validity, priority, and extent of all the water rights in a river basin or stream system.

Aquifer—An underground layer of porous rock, sand, and/or gravel that stores water in the spaces between grains, or through which water readily flows. The Middle Rio Grande's primary aquifer is the sandstone of the Santa Fe Formation.

Backwater, slough, yazoo, wet meadow, oxbow—Various marshy components of a river floodplain that owe their existence to overbank flooding, high groundwater, or to the morphological process by which a meandering stream abandons or isolates a portion of its former channel.

Biological assessment—Information prepared by or under the direction of a federal agency to determine whether a proposed action is likely to, (1) adversely affect listed species or designated critical habitat, (2) jeopardize the continued existence of species that are proposed for listing, or (3) adversely modify proposed critical habitat. Biological assessments must be prepared for "major construction activities." The outcome of a biological assessment determines whether formal consultation or a conference is necessary. [50 CFR §402.02, 50 CFR §402.12]

Biological opinion—A document which includes, (1) the opinion of the U.S. Fish and Wildlife Service or the National Marine Fisheries Service as to whether or not a federal action is likely to jeopardize the continued existence of listed species, or result in the destruction or adverse modification of designated critical habitat; (2) a summary of the information on which the opinion is based; and (3) a detailed discussion of the effects of the action on listed species or designated critical habitat. [50 CFR §402.02, 50 CFR §402.14(h)]

"Call" on the water—To exercise priority during a water shortage by limiting junior uses on a stream system until all senior rights have been served.

Cone of depression—A cone-shaped decrease in the water table around a wellhead, caused by suction; unless the water table receives adequate recharge, sustained pumping eventually draws groundwater from all directions, altering the overall path of its flow toward the well.

Conjunctive management—Managing and administering groundwater and surface water as a single, integrated resource.

Conservation easement—The permanent purchase by an organization, public agency, or community of the development rights to a parcel of open space or agricultural land to ensure that the property will remain unsubdivided.

Critical management areas—Zones where local hydrologic conditions require stringent administration by the State Engineer to prevent new appropriations of water from negatively impacting existing uses.

Ecosystem— A group of interdependent organisms together with the local environment they inhabit and depend on.

Evapotranspiration (ET)—Water released into the air from plant surfaces, or evaporated from the soil.

Exotics—Plant or animal species not native to a specific ecosystem or region.

Groundwater, ground-water, ground water: In all cases the word refers to water below the land surface, stored or flowing in the spaces between particles of soil. Different disciplines prefer one spelling or another: U.S. Geological Service and U.S. Fish & Wildlife Service hyphenate the term if it is used as an adjective (*e.g.*, 'ground-water supply'). Other professionals combine the two words into a single word when employing the term as a modifier, as in 'groundwater pumping.' Still others, including Postel and Ricter in *Rivers for Life*, have adopted the composite form for all occasions.

Holistic—Involving all of something; referencing a system as a whole rather than considering as separate its individual components, particularly its physical components.

Hydrograph—A graphic depiction of a river's unique high and low flow signature over time.

Jetty jacks—Steel structures, often with accompanying cable, implanted in and/or along the banks of a stream to prevent erosion and channel migration.

Middle Rio Grande—The river reach between Cochiti Dam and the headwaters of Elephant Butte Reservoir; also, the Middle Rio Grande water planning region, which encompasses the drainages of the Rio Jemez and Rio Puerco, and the mainstem Rio Grande from Cochiti Dam to the Valencia/Socorro County line.

NEPA—The National Environmental Policy Act of 1969 is a procedural law triggered by a discretionary federal action. If no federal action is being taken, no NEPA document is required. NEPA is a decision making process wherein federal agencies must consider the proposed action's environmental impacts as well as technical design considerations and costs. Depending on the level of NEPA compliance required (in relationship to the project's scope and associated impacts), the agency, with help from the public, identifies those significant environmental, social, and economic impacts that might occur should the proposal be implemented. Under the NEPA process, these more significant actions would be disclosed in an Environmental Assessment (EA) or Environmental Impact Statement (EIS). More routine actions would be covered under a Categorical Exclusion Checklist

(CEC) and do not generally require public input. The agency's responsibility is to determine alternatives that meet project objectives and hopefully best solve identified issues.

Phreatophytes—Trees or plants that generally have their roots in the water table and so may consume an excessive amount of moisture through evapotranspiration.

Phytoremediation—The process of employing living plants to filter specific chemicals or other pollutants from water, as in the use of constructed wetlands for tertiary treatment of wastewater.

Prior appropriation—A doctrine historically employed throughout the western United States that entitles those who first divert and use water from a stream to a priority, or *senior* right to that water. Diversions that occur later in time are considered *junior* appropriations and may be subject to curtailment in times of water shortage.

Prior and paramount water—Irrigation water for 8,847 acres belonging to the Pueblos of Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia and Isleta, with acknowledged priority under a 1928 agreement between the Department of the Interior and the Middle Rio Grande Conservancy District. As guaranteed by both federal law and the state's priority system, they are the most senior water rights in the middle Rio Grande valley.

Recharge—Water that replenishes an aquifer by way of infiltration from surface flows, or by artificial means such as injection wells. Not all water that seeps into the ground becomes recharge: evaporation can occur from the soil, and/or the water can be drawn up by plant roots and transpired into the air.

Return flow—Water that makes its way back to a stream system after diversion and use.

Rio Grande Compact—A 1939 interstate agreement between Colorado, New Mexico and Texas, administered by a commission with federal oversight that annually apportions the water of the Rio Grande according to the amount of native flow at proscribed points along the system. The agreement prohibits storage of Rio Grande flows in upstream reservoirs constructed after 1929 if the water level at Elephant Butte Reservoir falls below 400,000 acre-feet.

Rotation—An irrigation schedule that allows all the users on a particular ditch access to the water by turns.

San Juan-Chama (SJC)—Water diverted by way of an engineered system into the Rio Grande basin from the San Juan basin by the Bureau of Reclamation, and contracted to various entities, including municipalities and the Middle Rio Grande Conservancy District. On average since 1972, between 108,000 and 110,000 acre feet of SJC water has augmented native Rio Grande flows annually, although diversions are limited by the available supply in any given year. The imported water is not subject to the conditions of the Rio Grande Compact and can therefore be stored in specified New Mexico reservoirs when a debit exists at Elephant Butte Reservoir.

Sustainable— A 'sustainable' practice might be defined as one that meets present needs without exhausting a necessary resource or impairing the ability of future generations to meet *their* needs. Two things to consider: 'Exactly what is to be sustained?' and 'In what time frame?'

"*Take*"—Loss of individuals of an endangered species due to human activity, punishable by fine under the Endangered Species Act.

Unaccounted-for water—The difference between what is pumped into a municipal or community water distribution system and the total water billed to individual accounts. It includes any water that leaks from broken or degraded pipes, broken water meters, and fire hydrants. Most, if not all, southwestern cities include unaccounted-for water in their calculation of daily per capita use.

Vested rights—In New Mexico, surface water rights in use before 1907, or groundwater rights established before designation of a groundwater basin by the State Engineer. (Also referred to as pre-1907 rights.)

Water budget—A balance sheet indicating all water inflows to a specified region, how much of it is consumed or depleted within the region by which use sectors, and how much of it flows out of the region.

W.A.T.E.R.S.—Water Administration Technical Engineering Resource System, a database of water right files for each basin under development by the Office of the State Engineer, and available to the public on the OSE website. (As of December 2004, analysis had been completed on the Tularosa, Hueco, Hot Springs, Las Animas Creek, Salt, Fort Sumner, Gallinas River, Rio Chama, Bluewater, Zuni, Sandia, Virden Valley and Peñasco basins. Files for the San Juan were 80% complete; the Mimbres, 60% complete; and Nambe, Pojoaque and Tesuque basins 25% complete. Files for the Lower Rio Grande were complete but current adjudication information had not been abstracted.)

Wet water—Actual liquid as opposed to the legal paperwork that represents a water right. The need for the distinction arises in an over-appropriated stream system where more water has been allocated than the system can physically provide. In the middle Rio Grande basin, it has been estimated there may be four times as many water rights as there is wet water to serve them.

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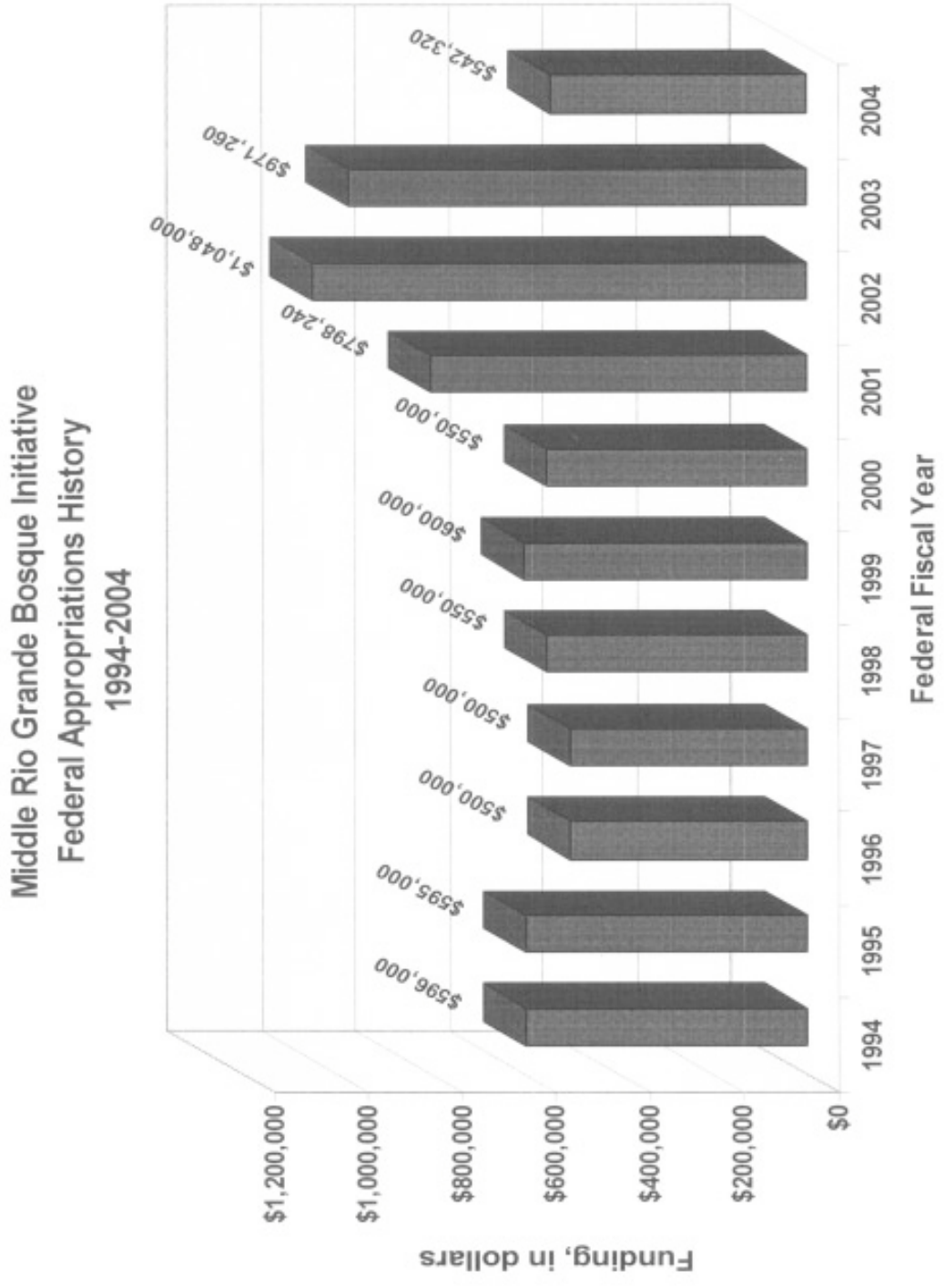
Appendix A


Middle Rio Grande Bosque Initiative
Federal Appropriations History
1994-2004
Funding, in dollars
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
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1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Federal Fiscal Year
$596,000
$595,000
$500,000
$500,000
$550,000
$600,000
$550,000
$798,240
$1,048,000
$971,260
$542,320

Appendix B

Bosque Initiative/BIG Projects

[Note: Project reporting format was modified in 2001]

Appendix B.1--FY1994 Middle Rio Grande Bosque Initiative Funded Projects

Project title
RESEARCH:
Effects of Controlled Groundwater Salinity Concentrations on Germination, First-Year Establishment, and Growth of Rio Grande Cottonwood and Saltcedar
Vertebrate Use of Artificially Revegetated and Naturally Vegetated Riparian Sites on Bosque del Apache National Wildlife Refuge
Patch Size, Biodiversity, and Wildlife Values in Fragmented Rio Grande Bosque; The Example of Non-Contiguous Habitats
A Comparison of Mechanical and Herbicide/Burn Saltcedar Control Techniques
Manipulative Flooding Study
Water Measuring at Units 26 and 27 (UNM Study Site)
Water Management Development for Unit 27 (UNM Study Site)
MONITORING:
GIS Support and Long-Term Monitoring for the Middle Rio Grande
Geo-hydrological Data Management, Support, and Long-Term Monitoring
Continued Monitoring and Report Preparation for Refuge Study, "The Effects of Soil Disturbance on the Germination of Riparian Woody Plants Within the Floodplain of the Rio Grande in Central New Mexico"
Continued Monitoring and Report Preparation for Refuge Revegetation Program
HABITAT:
Small Riparian/Wetland Project
Small Riparian/Wetland Project
Small Riparian/Wetland Project
Pueblo of Isleta Wildlife Management Project
Wetland/Riparian Habitat Management on Private Farm in Belen, NM
Wetland/Riparian Habitat Management on Private Farm in Algodones, NM
Unit 31, Complete Salt-Cedar Control and Water Control Potential
Unit 32, Complete Salt-Cedar Control and Water Control Potential
OUTREACH:
Bosque/Middle Rio Grande Corridor Educator Handbook
Resource Education Trunks and Site Packs
Model(s) of the Rio Grande Valley and the Substrate and Water Table
New Mexico Project Wild Bosque Workshops/Education Material
Water Ecology Research Project (New Mexico Museum of Natural History: 7th-8th Grade Math/Science Program)
Old Town Natural History Project
Interactive Display - conversation to CD Rom
Regional Bosque Library
COORDINATION:
January Bosque Meeting
Coordination Position/Support
TOTAL: $600,000

Appendix B.2--FY1995 Middle Rio Grande Bosque Initiative Funded Projects

Project title
RESEARCH:
The Role of Flooding on Cottonwood and Saltcedar Sites
Patch Size, Biodiversity, and Wildlife Values in Fragmented Rio Grande Bosque; The Example of Non-Contiguous Habitats
Temporal and Spatial Controls of Salinity Model Development
Records Search: Introduction and Stocking of Non-Native Fish Species in the Rio Grande Basin, New Mexico
MONITORING:
Geo-hydrological Data Management, Support, and Long-Term Monitoring
HABITAT:
Unit 31 Riparian Restoration, Bosque del Apache National Wildlife Refuge
Unit 32 Riparian Restoration, Bosque del Apache National Wildlife Refuge
Firebreak Enhancement, Bosque del Apache National Wildlife Refuge
Revegetate Miscellaneous Areas, Bosque del Apache National Wildlife Refuge
A Comparison of Mechanical and Herbicide/Burn Saltcedar Control Techniques, Bosque del Apache National Wildlife Refuge
Collect Data on the Applicability of Overbank Flooding as it Relates to Regeneration of Cottonwood Trees
Conduct Moist Soil Management on Land Adjacent to the Rio Grande Nature Center
Develop Wetland/Riparian Habitat near the Intersection of Rio Grande Boulevard and Alameda Road
Rehabilitation of the Bernardo Waterfowl Management Area
Riparian Vegetation Establishment and Restoration Research Support
OUTREACH:
Information and Education - U.S. Fish and Wildlife Service/Regional Office
Save Our Bosque Task Force - Interpretation and Education Along the Lower Middle Rio Grande
COORDINATION:
Coordination Position/Support
TOTAL: $600,000

Appendix B.3--FY1996 Middle Rio Grande Bosque Initiative Funded Projects

Project title
RESEARCH:
Influence of Seasonal Flooding on Ecosystem Dynamics Underlying Partial Restoration of the Middle Rio Grande Bosque
Patch Size, Biodiversity, and Wildlife Values in Fragmented Rio Grande Bosque (Year 3 of3)
Feasibility Study for Ecosystem Restoration on the Middle Rio Grande
Temporal and Spatial Controls of Salinity Model Development (Year 2 of 3)
MONITORING:
Geo-hydrological Studies, Data Management, Support, and Long-Term Monitoring
Geomorphic Characterization of Middle Rio Grande
Assemblage of Research and Existing Data
Rio Grande Bosque Vegetation Mapping
Aerial Photography Fly
HABITAT:
On-Refuge Habitat Enhancement, Bosque del Apache National Wildlife Refuge
Off-Refuge Habitat Enhancement
Sling Pump Proposal
Surface-Water Data Collection Project
Riparian Vegetation Establishment and Restoration Research Support
OUTREACH:
Publication on Middle Rio Grande Riparian Area
Teacher Workshops for Bosque Curriculum
Save Our Bosque Task Force - Interpretation and Education Along the Lower Middle Rio Grande
COORDINATION:
Coordination Position/Support
TOTAL: $500,000

Appendix B.4--FY1997 Middle Rio Grande Bosque Initiative Funded Projects

Project title
RESEARCH and Monitoring:
Bat Distribution and Diversity on the Sevilleta and Bosque del Apache National Wildlife Refuges
Crops for Wildlife (Survey and 2 Feasibility Study reports, Applied Ecology, Wildlife and Agricultural Research)
Recovery From Fire of Experimentally and Naturally Flooded Riparian Sites at Bosque del Apache National Wildlife Refuge
Temporal and Spatial Controls on Soil Salinity in the Bosque del Apache
Middle Rio Grande Wildland Fire Monitoring (Establishment of Permanent Photographic Points at Fires in 1997)
Rio Grande Bosque Invasive Weed Management (Survey for Invasive and Noxious Weeds in the Middle Rio Grande Bosque
Albuquerque Open Space, Rio Grande Valley State Park Database (GPS-AGIS)
HABITAT:
Establishment of Native Riparian Flora Using Controlled Flooding at Bosque del Apache National Wildlife Refuge
Bernardo State Wildlife Area, Waterfowl/Wetland/Moist Soil Management Unit Development
Santa Ana Micorrhizae Development Project, Santa Ana Pueblo
Partners for Wildlife
Natural Resources Conservation Service/Plant Materials Center - Riparian Vegetation Establishment and Restoration Research Support
OUTREACH:
Socorro Natural Area, Socorro Riverine Recreational Area, Educational, Interpretive
River Voices: Rio Grande/Rio Bravo
Middle Rio Grande Bosque Newsletter
Bosque Education Guide
Bosque Ecographic Poster
COORDINATION:
Hydrologic Data Coordination and General Support
Vegetation Reclassification after Hink and Ohmart
Monitoring Coordinator/Information Management
GIS Database Development: 1922 Middle Rio Grande Survey Maps
Computer Modeling of Flood Flows in the Middle Rio Grande
Coordination Position/Support
TOTAL: $500,000

Appendix B.5--FY1998 Middle Rio Grande Bosque Initiative Funded Projects

Project title
RESEARCH and Monitoring:
Santa Ana Pueblo - Rio Jemez Salinity Study
River Bars of the Rio Grande
Fragmentation and Restoration of the Middle Rio Grande Cottonwood Forest
Ecological Monitoring: Middle Rio Grande Bosque
Salinity Management for Ecological Restoration of the Middle Rio Grande Bosque
Bosque Hydrology Group/Field Surveying for Calibration of FLO-2D Model
Hydrology Coordinator
Bosque Vegetation Reclassification
HABITAT:
Sevilleta National Wildlife Refuge Wetland Development
Save our Bosque Taskforce - San Pedro Burn Rehab
City of Albuquerque - Anderson Fields
Albuquerque Open Space - Salt Cedar Removal
Sandia Pueblo - 20-Acre Restoration Demonstration Project
OUTREACH:
Sweetwater Reclamation - Noxious Weed Brochure Exhibit
Tides Foundation - Bosque Interpretive Poster
Tides Foundation - Watershed Map for Poster/Document Uses
Forest Service Research/BIG- Bosque initiative Symposium/Workshop
Rio Grande Nature Center - Nature Exhibit
Rio Grande Nature Center - River Model
Gathering of Waters
All Indian Pueblo Council - Pueblo Outreach
COORDINATION:
Coordination Position/Support
TOTAL: $550,000

Appendix B.6--FY1999 Middle Rio Grande Bosque Initiative Funded Projects

Project title
RESEARCH and Monitoring:
River Bars of the Rio Grande (Year 2 of 3)
Fragmentation and Restoration of the Middle Rio Grande
Ecological Monitoring - Middle Rio Grande Bosque
Salinity Management for Ecological Restoration of the Middle Rio Grande Bosque
Riparian Recruitment by Flooding Study at Bosque del Apache National Wildlife Refuge (Final Year)
Ecology of Whitetop (Lipidium latifolium) (Year 1 of 3)
HABITAT:
Save Our Bosque Task Force/Socorro County Rehabilitation/Protection Project
La Joya Salt Cedar Control, Unit 4 & 5 (200 acres)
Working Group Meeting: Solutions to Native Riparian Habitat Restoration within the Current Rio Grande Floodplain
Unit 8 Riparian/Wetland Development, Bosque del Apache National Wildlife Refuge
Unit 31 Riparian Restoration
Bosque Habitat Enhancement and Fire Protection Project
Santa Ana Pueblo Bosque Restoration Project
Development of a Micro-Flooding Pump System to Enable Natural Cottonwood Regeneration (Year 1 of 3)
OUTREACH:
Printing of the Bosque Eco-Graphic
Bosque Video
Bosque "Coffee Table Book"
Rio Grande Ecology Institute
Restoring the Middle Rio Grande: A Community Action Plan - Listening Project
Bosque Consortium, Middle Rio Grande Council of Governments
COORDINATION:
Coordination Position/Support
TOTAL: $600,000

Appendix B.7—FY2000 Middle Rio Grande Bosque Initiative Funded Projects

Project Title
Research and Monitoring
NM Heritage-River Bars/Insects of the Rio Grande (ongoing)
Texas Tech Riparian Recruitment by flooding study at Bosque del Apache NWR (long term monitoring)
Ecology of Whitetop (Lipidium latifolium) University of Missouri/Gaylord Lab-Bosque del Apache and Sevilleta National Wildlife Refuges (year 2 of 3)
UNM Ecological Monitoring-Middle Rio Grande Bosque (ongoing)
NM Tech-Salinity Mgt. For Ecological Restoration in the Middle Rio Grande Bosque
MiniMax Corp.-Development of a Micro-Flooding Pump System to Enable Natural Cottonwood Regeneration (year 2 of 3)
Habitat Enhancement/Restoration
Partners for Fish and Wildlife
Pueblo of Santa Ana river/riparian area restoration
New Mexico Department of Game and Fish Bernardo/La Joya/Casa Colorada Improvements
Albuquerque Open Space
Private lands
Middle Rio Grande Conservancy District/Other State Lands (i.e. Nature Center)
On Refuge Habitat Enhancement, Bosque del Apache and Sevilleta National Wildlife Refuges
Federal Agency (Corps of Engineers/Bureau of Reclamation Priorities)
Outreach:
Rio Grande Ecology Institute-Rio Grande Nature Center
Restoring the Middle Rio Grande: A Community Action Plan-Listening Project
Bosque Video to be prepared by Cooney & Associates (Part of a Six Part Series)
Save our Bosque Task Force/Socorro County Rehabilitation/Protection Project
Bosque "Coffee Table Book" in development by the Public Lands Interpretive Association
Coordination:
Coordination Position/Support
Total: $550,000

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects

[R, research; M, monitoring; O, outreach; H, habitat; --, no data.]

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
Research: $144,000							
R,H,M	Restoration of Native Riparian Flora	Bosque del Apache NWR	--	Texas Tech University	Loren Smith/ John P. Taylor	4th year	Research project to provide requisite knowledge to maximize native riparian flora recruitment on active river floodplain and on controlled flooding areas outside the floodplain.
R,H	Development of a Micro-Flooding Pump System to Enable Natural Cottonwood Regeneration	Middle Rio Grande Bosque Corridor	--	MiniMax, Inc.	Edmund E. Spaeth	3rd year	Development of a self-contained, automated pump system to produce localized irrigation from a shallow well during normal cotton dispersal, germination and seedling growth I the Bosque; three active field sites with 115 cottonweed seedlings are located in a 30-uear old bosque burn site in Corrales.
R,H	Ecology of Tall Whitetop in the Upper/Middle Rio Grande Ecosystem	Bosque del Apache NWR	--	University of Missouri/Gaylor d Lab	Leigh Fredrickson	2nd year	Study to evaluate control practices of tall whitetop, an invasive plant that compromises natural ecosystems; results may potentially identify treatments to reduce established stands.
R,H,M	River Bars of the Middle Rio Grande	Middle Rio Grande	--	University of New Mexico	Esteban Muldavin	3rd year	Study to evaluate the range of biological variability of river bars in relation to environmental characteristics aiding the conservation, restoration and enhancement of ecological values.
R	Regional Assessment of Soil Salinity in the Rio Grande Floodplain	Rio Grande Flood Plain,	--	New Mexico Institute of Mining and Technology	Bruce Harrison/ Jan Hendrickx	3rd year	Study to establish a relationship between remote sensed imagery and soil salinity which will allow for prediction of soil salinity of large areas of the Rio Grande Bosque.

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
R	FLO-2D Model Presentation Manipulations	Rio Grande Flood Plain, Socorro County	--	U.S. Bureau of Reclamation	Mark Nemeth	1st year	A two-dimensional flow model will be used for river restoration design and flood plain delineation and to distinguish the 10,000 cubic feet per second and 100-year flood on the reach of river from San Acacia Dam to headwaters of Elephant Butte Reservoir.
R	Riparian Ecosystem Restoration: Effects of Flooding and Vegetation Type on Evapotranspiration along the Middle Rio Grande	Albuquerque south to Bosque del Apache	--	University of New Mexico	Dr. Cliff Dahm/ Dr. James Cleverly	1st year	Study to: determine annual evapotranspiration (ET) rates for native and non-native riparian plant communities; assess the effect of flooding on annual ET; evaluate inter-annual variability in ET; and contribute calibration parameters to the Middle Rio Grande water budget.
Monitoring: $119,500							
M,O	Bosque Ecosystem Monitoring Program	Middle Rio Grande	--	University of New Mexico	Clifford S. Crawford	4th year	Long term ecological monitoring using an outreach approach for participants to understand the changing dynamics of the Middle Rio Grande riparian forest.
				Bosque School	Mary Stuever		
M	Inventory and Mapping of Vegetation of the Jemez River Delta, Santa Ana Pueblo	Santa Ana Pueblo	--	Pueblo of Santa Ana	Todd Caplan	3rd year	Wildlife and vegetation monitoring program to assess changes associated with the Pueblo's Bosque restoration efforts.
M,H,O	Los Lunas River Park Project	Los Lunas, NM	--	Tree New Mexico, Inc.	Suzanne Probart	1st year	Restoration and establishment of a mixed-use River Park area along the Rio Grande.
M	Endangered Species Monitoring on Private Lands	Socorro County, NM	--	Save Our Bosque Task Force	Wess Anderson/ Doug Boykin	1st year	Perform comprehensive surveys for endangered species occurrence on private lands within Socorro County.

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
M	Willow Flycatcher Survey	Sevilleta NWR	--	U.S. Fish and Wildlife Service/ Sevilleta NWR	Terry Tadano	1st year	Perform southwestern willow flycatcher surveys on Sevilleta NWR.
Habitat Enhancement/Restoration: $267,000							
H,O	Feasibility Study of Easement/Restoration Program along Rio Grande	Socorro County, NM	--	Save Our Bosque Task Force	Gina Dello Russo	1st year	Assessment of land ownership, access/utilities, vegetation, floodplain delineation, etc., and estimate of restoration costs based on exotic vegetation component for a potential restoration program along the Rio Grande floodplain.
H,O	Demonstration Project: Regeneration of Bosque Cottonwood within Decrepit Stands Using the SPRED Groundwater Redistribution System	Middle Rio Grande Bosque Corridor	--	MiniMax, Inc.	Edmund E. Spaeth	1st year	Transplant up to 100 cottonwood seedlings in the Corrales Bosque Preserve following removal of excess fuel and exotic species and demonstration of the SPRED ground-water redistribution system.
H	San Antonio Oxbow Wetland and Riparian Restoration Project	San Antonio Oxbow	--	City of Albuquerque/ Open Space Division	Ondrea Linderoth-Hummel	1st year	Removal of sediment/dam material and cattail and trenching for creation of a continuous waterway through the oxbow to the river.
H	Save Our Bosque Task Force/Socorro County Bosque Rehabilitation/Protection Project	Socorro County, NM	--	U.S. Fish and Wildlife Service/ Sevilleta NWR	Doug Boykin	5th year	Exotic species control/fuels reduction in and around cottonwood and willow stands between San Acacia Dam and the north boundary of Bosque del Apache NWR, using manual and mechanical treatment and individual herbicide application.
H	Phase II Saltcedar Control - Unit 32	Bosque del Apache NWR	--	U.S. Fish and Wildlife Service/ Bosque del Apache NWR	John P. Taylor	3rd year	Salt cedar control, aerial clearing, root plowing and root raking of 200 acres on Bosque del Apache NWR for conversion to riparian and moist soil habitats.

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H	Pilot Restoration Project-Private Land A; on the Rio Grande, Socorro County	Save Our Bosque Task Force	--	Save Our Bosque Task Force	Gina Dello Russo	1st year	Removal of young exotic vegetation from a river point bar, removal of mature exotic tree species from a salt grass meadow area, and planting of appropriate native vegetation from salt grass meadow area; demonstration project on 17 acres of wetland.
H	Pilot Restoration Project-Private Land B: on the Rio Grande, Socorro County	Save Our Bosque Task Force	--	Save Our Bosque Task Force	Gina Dello Russo	1st year	Removal of exotic species and revegetation with suitable native species of trees to replace the existing open structure of the area east of Escondida Drain and removal of exotic trees and open ground maintenance to restore native vegetation west of the drain; demonstration project on 25 acres of wetland.
H,R	Polvadera Wetland	Polvadera, NM	--	U.S. Fish and Wildlife Service/ Partners for Fish and Wildlife	Chuck Mullins/ Ross Coleman	1st year	Creation of a 0.5-acre wildlife wetland and associated 0.5-acre riparian and upland habitat on former Rio Grande floodplain at Polvadera, NM.
H	Protect Native Forests from Wildfire	Bosque del Apache NWR	--	U.S. Fish and Wildlife Service/ Bosque del Apache NWR	John P. Taylor	1st year	Mechanical removal of salt cedar from 100-foot wide firebreaks constructed around four large blocks consisting of about 80 acres and treatment of 35 acres of salt cedar regrowth on Bosque del Apache NWR.
H,M,R	Middle Rio Grande Conservancy District Bosque Fuels Reduction	Middle Rio Grande Bosque Corridor	--	Middle Rio Grande Conservancy District	Subhas K. Shah	3rd year	Mechanical removal of dead and down wood and exotic trees, treatment of cut stumps; downed woody material will be bucked and piled; large diameter wood will be provided to the community and small diameter material will be chipped and/or burned.

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects--*Concluded*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H	Bosque Fuel Reduction Project	Albuquerque, NM	--	City of Albuquerque/ Open Space Division	Ondrea Linderoth-Hummel	1st year	Removal of fuel loads including branches, leaves, dead trees and exotic species on 50 acres of Rio Grande Valley State Park; included are follow-up spraying of exotic species and planting of native understory.
H	Fire Breaks on Flood Plain of Rio Grande, Socorro County	Socorro County, NM	--	Socorro Soil and Water Conservation District	Doug Boykin	1st year	Construction of 200-foot wide firebreaks around designated forests where endangered species clearance and private land owner permission has been obtained; understory clearing of exotic vegetation in areas where dense, tall vegetation would carry flames into canopy, and planting of native grasses t control return of exotic species of trees and noxious weeds, and clearing of exotic vegetation clogging arroyo mouths and reconnecting of arroyos.
H	Brush Removal and Fire Break Project	Middle Rio Grande	--	U.S. Fish and Wildlife Service/ Sevilleta NWR	Terry Tadano	1st year	Removal of salt cedar growing along the Rio Grande and creation of a fire break to help preserve the larger, mature cottonwoods in wetland area of Sevilleta NWR.
H	Jemez-USFW Bosque Improvement Project	Jemez Pueblo	--	Pueblo of Jemez	Mehrdad Khatibi	1st year	Production of a Bosque Restoration Plan for the Pueblo of Jemez. Plan will include tasks for removal and treatment of saltcedar and Russian olive plants within the riparian habitat along the Jemez River.
H	Removal of Salt Cedar and Other Exotics	San Lorenzo Canyon	--	U.S. Fish and Wildlife Service/ Sevilleta NWR	Terry Tadano	1st year	Removal of salt cedar from the San Lorenzo Canyon area.

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H	Pueblo of Sandia Restoration Project	Sandia Pueblo	--	Pueblo of Sandia	Beth Janello	1st year	Restoration project to improve native wildlife by replacing non-native plant species with appropriate native plant species.
H	Restoration along Los Chavez Drain near Los Lunas	Los Chavez, NM	--	U.S. Fish and Wildlife Service/ Partners for Fish and Wildlife	Chuck Mullins	1st year	Implementation of an erosion control pilot project to remove non-native vegetation along a 1-mile section of the Los Chavez Drain near Los Lunas, NM, to reshape the ditch to a flatter slope, and to revegetate the ditch banks with native vegetation.
H,O	Pueblo of Cochiti Restoration Project	Cochiti Pueblo	--	Pueblo de Cochiti	Jacob Pecos	1st year	Restoration project to protect and rehabilitate the bosque enhancing the biodiversity and ecological resources within the boundaries of the Pueblo de Cochiti.
Outreach: $159,500							
O	Bosque Education Guide Update -- Year 2	Middle Rio Grande Bosque Corridor	--	Friends of the Rio Grande Nature Center State Park	Mary Stuever	2nd year	Update of education guide expanding current activities to address mitigation, water planning, and other timely topics, create new activities for a broader target audience, update information on contacts, natural history, resources, etc., and cross-reference to education standards.
O	Restoring the Middle Rio Grande: A Community Action Plan	Middle Rio Grande Valley, NM	--	Rio Grande Restoration	Deborah Hibbard	3rd year	Develop and implement a River Advocate training program to enable participants to become further informed about the river and to explore complex issues and action opportunities.
O	Bosque Hydrology Group	Middle Rio Grande	--	U.S. Fish and Wildlife Service/ Water Resources Division	Paul Tashjian	6th year	Coordinate and synthesize hydrologic data within the Middle Rio Grande as they relate to the restoration of the bosque and maintain web page for information distribution.

Appendix B.8—FY2001 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
O	Rio Grande Ecology Institute (Year 2)	Middle Rio Grande Bosque Corridor	--	Friends of the Rio Grande Nature Center State Park	Dr. Karen E. Brown	2nd year	Four-week summer program designed for high school sophomores and juniors to study the biology, hydrology, water management, aquatic ecology and endangered species of the bosque.
O	ABQ Bosque Restoration - Public Education and Participation	Albuquerque, NM	--	Rio Grande Restoration	Deborah Hibbard	1st year	Expand public education and recruit and organize community involvement in ecological restoration of 5-acres of a 10-acre site along Tingley Drive.
O	Student Ecology Research	Middle Rio Grande	--	New Mexico Museum of Natural History and Science	Tim Aydelott	2nd year	Provide research education and experience for 48-60 students from Bernalillo, Los Lunas, Belen, and Socorro high schools; training opportunities in aquatic and terrestrial ecology research techniques, design and implementation of long-term monitoring sites in each community.
O	Develop Educational Materials and Positive Relationships with Local Communities	Sevilleta NWR	--	U.S. Fish and Wildlife Service/ Sevilleta NWR	Terry Tadano	1st year	Development and implementation of an educational curriculum that focuses on the importance of the cottonwood bosque/riverine habitat and ways in which community members can work toward enhancing, restoring, and saving the native riparian forests.
O,R,H,M	Jardines del Bosque	Middle Rio Grande	--	National Hispanic Cultural Center of New Mexico	Carlos Vasquez	1st year	Establishment of a Research Center located within the Cultural Center facility and adjacent 12-acre bosque site that will serve as an outdoor laboratory and study center for the community to learn and research the wildlife and natural habitat of the bosque.
O,M,H	Middle Rio Grande Ecosystem: Bosque Biological Management Plan Update and Implementation Project	Middle Rio Grande	20	Rio Grande Restoration	Deborah Hibbard	1st year	Development of an update and implementation plan that will supplement the Middle Rio Grande Bosque Biological Management Plan (Crawford, et al., 1993).
Coordination/Administration: $108,240							
TOTAL: $798,240							

Appendix B.9—FY2002 Middle Rio Grande Bosque Initiative Funded Projects

[R, research; M, monitoring; O, outreach; H, habitat; --, no data.]

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
Research: $256,400							
R	Ecology of Tall Whitetop in the Upper/Middle Rio Grande Ecosystem	Upper/Middle Rio Grande	4,8,10,14,15,16, 17,18	University of Missouri/Gaylor d Laboratory	John Taylor, Leigh Fredrickson	3rd year	Study to evaluate control practices of tall whitetop, an invasive plant that compromises natural ecosystems; results may potentially identify treatments to reduce established stands.
R	Restoration of Native Riparian Flora	Bosque del Apache NWR	8,14,16,17,18, 19, 21	Texas Tech University	John Taylor, Loren Smith	2nd year	Research project to provide requisite knowledge to maximize native riparian flora recruitment on active river floodplain and on controlled flooding areas outside the floodplain.
R	River Bars of the Middle Rio Grande -- Phase II (Continued)	Middle Rio Grande	2,7,8,15,16,17, 18	University of New Mexico	Dr. Esteban Muldavin	4th year	Study to evaluate the range of biological variability of river bars in relation to environmental characteristics aiding the conservation, restoration and enhancement of ecological values.
R	Habitat Requirements of the Southwestern Willow Flycatcher in the Middle Rio Grande Valley	Middle Rio Grande Valley	19	University of New Mexico	Dr. Peter B. Stacey	1st year	Assess the habitat requirements of the southwestern willow flycatcher to better understand the endangered bird's nesting and territory selection process.
R,H	Middle Rio Grande FLO-2D Model Development and Calibration Proposal for Middle Rio Grande Bosque Initiative	Middle Rio Grande	1,2,9,21,22,23, 8,15	Tetra Tech, Inc.	Douglas F. Wolf, PE	1st year	Provide calibration and detailed model application of the Middle Rio Grande FLO-2D Model that will be used to predict overbank flooding and floodwave attenuation on the Middle Rio Grande. Model results will aid in restoration planning.
R,H, O,M	Jardines del Bosque Research Station: Urban Ecology on the Rio Grande	Rio Grande bosque	4,5,7,8,9,11,12, 13,14,15,16,17, 18,19,20,21	National Hispanic Cultural Center of New Mexico	Carlos Vasquez	2nd year	Establishment of a Research Center located within the Cultural Center facility and adjacent 12-acre bosque site that will serve as an outdoor laboratory and study center for the community to learn and research the wild life and natural habitat of the bosque.

Appendix B.9—FY2002 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
R,M	Water Use by Middle Rio Grande Phreatophytes, Monitoring the contributions of Russian Olive, Saltcedar, and Cottonwood	Middle Rio Grande	3,17,18,19,21	University of New Mexico	James Cleverly, Dr. Cliff Dahm	2nd year	Study to determine annual evapotranspiration (ET) rates for native and non-native riparian plant communities; assess the effect of flooding on annual ET; evaluate interannual variability in ET; and contribute calibration parameters to the Middle Rio Grande water budget.
R,M, O	Bosque Hydrology Group, FLO 2D Workgroup	Middle Rio Grande	1,2,3,21,4,5,7,8, 15,16	U.S. Fish and Wildlife Service/ Water Resources Division	Paul Tashjian	7th year	Coordinate and synthesize hydrologic data within the Middle Rio Grande as they relate to the restoration of the bosque and maintain web page for information distribution. Coordinate Bosque Hydrology Group and FLO-2D Workgroup.
Monitoring: $127,000							
M	Rio Grande Water-Quality Monitoring	Rio Grande from NM 44 south to Alameda Bridge	5	Pueblo of Sandia	Elizabeth Janello	1st year	Implement surface-water monitoring and establish a baseline of water-quality parameters in the Rio Grande from NM44 south to Alameda Bridge.
M	Monitoring the breeding population of raptors and owls in the Middle Rio Grande riparian corridor	Middle Rio Grande	18	Hawks Aloft, Inc.	Christopher Rustay	1st year	Conduct a complete survey of the population of breeding raptors and owls to determine species composition and breeding pair density, monitor active nests for success, productivity, food habits, habitat characteristics, and disturbance factors.
M,H	Socorro County Invasive/Noxious Weed Management Area Control Project	Socorro County	3,5,8,9,13,15, 16,17	Socorro Soil and Water Conservation District	Nyleen Stowe	1st year	Removal of noxious weed species to enhance riparian zones, wetland areas, reduce fire danger, and protect the ecosystem.
M,O	Bosque Ecosystem Monitoring Program (BEMP)	Middle Rio Grande riparian forest/bosque	18, all indirectly	University of New Mexico/Bosque School	Dr. Cliff Crawford	5th year	Long term ecological monitoring using an outreach approach for participants to understand the changing dynamics of the Middle Rio Grande riparian forest.

Appendix B.9—FY2002 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
M	Willow Flycatcher Survey	Sevilleta National Wildlife Refuge and La Joya Wildlife Refuge	--	U.S. Fish and Wildlife Service/ Sevilleta NWR	Deb Davies, Dawn Citrin	2nd year	Perform southwestern willow flycatcher surveys on Sevilleta National Wildlife Refuge.
Habitat Enhancement/Restoration: $421,700							
H	Save Our Bosque Task Force/Socorro County Bosque Rehabilitation/Protection Project	Upper/Middle Rio Grande	7,8,9,11,12,13, 14,15,16,17,18	Save Our Bosque Task Force	Doug Boykin	6th year	Exotic species control/fuels reduction in and around cottonwood and willow stands between San Acacia Dam and the north boundary of Bosque del Apache NWR, using manual and mechanical treatment and individual herbicide application.
H	Stream habitat restoration on Las Huertas Creek near Placitas, New Mexico, a tributary to the Rio Grande north of Albuquerque (Private Land Project]	La Huertas Creek near Placitas	4,5,14,16,17	U.S. Fish and Wildlife Service/ Partners for Fish and Wildlife	Denise Smith	1st year	Halt erosion occurring on a 2,600 foot section of Las Huertas Creek, stabilize the channel bottom and stream banks, and restore native vegetation to maintain a stable channel.
H	Pueblo of Jemez -- Bosque Improvement Project	Jemez River riparian corridor/Jemez Reservation	--	Pueblo of Jemez	Mehrdad Khatibi	2nd year	Production of a Bosque Restoration Plan for the Pueblo of Jemez. Plan will include tasks for removal and treatment of saltcedar and Russian olive plants within the riparian habitat along the Jemez River.
H	Unit 34A Riparian Wetland Development	Bosque del Apache NWR	1,3,4,7,8,11,13, 14,15,16,17	U.S. Fish and Wildlife Service/ Bosque del Apache NWR	John Taylor	1st year	Develop a quality southwestern willow flycatcher habitat on Bosque del Apache NWR.
H,R	Middle Rio Grande Bosque Fuels Reduction Study	Middle Rio Grande Bosque Corridor	7,8,10,11,13,14, 16,17	Middle Rio Grande Conservancy District	Subhas K. Shah	3rd year	Mechanical removal of dead and down wood and exotic trees, treatment of cut stumps; downed woody material will be bucked and piled; large diameter wood will be provided to the community and small diameter material will be chipped and/or burned.

Appendix B.9—FY2002 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H	The Restoration of the Bosque Ecosystem from the Cochiti Dam Outlet to the Southern Reservation Boundary, Pueblo de Cochiti, Cochiti NM	Cochiti Dam outlet to the southern Pueblo de Cochiti reservation boundary	8,9,11,14,16	Pueblo de Cochiti	Dr. Don Diego Gonzalez, Jacob Pecos	2nd year	Restoration project to protect and rehabilitate the bosque enhancing the biodiversity and ecological resources within the boundaries of the Pueblo de Cochiti.
H	Brush Removal and Fire Break Project	Sevilleta National Wildlife Refuge	13,17	U.S. Fish and Wildlife Service; Sevilleta NWR	Deb Davies, Dawn Citrin	2nd year	Removal of salt cedar growing along the Rio Grande and creation of a fire break to help preserve the larger mature cottonwoods in wetland area of Sevilleta NWR.
H	Los Poblanos Field Wetland	Los Poblanos Farm Open Space	--	City of Albuquerque/ Open Space Division	Ondrea Hummel, Todd Miller	1st year	Create a 5-acre wetland for use by migrating and resident birds and other wildlife species.
H	Fuel Reduction Research and Prescription Implementation Project	Rio Grande Valley State Park	--	City of Albuquerque/ Open Space Division	Ondrea Hummel, Jodi Hedderig	2nd year	Removal of fuel loads including branches, leaves, dead trees and exotic species on 50 acres of Rio Grande Valley State Park; included are follow-up spraying of exotic species and planting of native understory.
H	Bosque Pond Restoration	Pueblo of Sandia Bosque	4,5,14,15,16	Pueblo of Sandia	Elizabeth Janello	2nd year	Enhance and restore six surface-water ponds located in the Pueblo of Sandia Bosque to their historical state: natural wetlands.
H,M, O	Implementation Plan for Bosque Biological Management Plan	Middle Rio Grande	20, 21, implications for all	Rio Grande Restoration	Deb Hibbard	2nd year	Development of an update and implementation plan that will supplement the Middle Rio Grande Ecosystem: Bosque Biological Management Plan (Crawford et al., 1993).
H,O	Los Lunas River Park Project	Los Lunas	4,6,7,9,11,12, 13,14,16	Tree New Mexico, Inc.	Suzanne Probart	2nd year	Restoration and establishment of a mixed-use River Park area along the Rio Grande.
H,O	Unit 10 Riparian Forest and Grassland Development	Bosque del Apache NWR	8,9,13,14,15	U.S. Fish and Wildlife Service/ Bosque del Apache NWR	John Taylor	1st year	Improve and protect a four-acre native riparian salt grass meadow and savannah forest from wildfire and introduce the public to rehabilitation techniques and this diverse plant community.

Appendix B.9—FY2002 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H,O	San Acacia to San Marcial Reach of the Rio Grande; Restoration and Rehabilitation Plan	San Acacia to San Marcial Reach of the Rio Grande	1,2,3,4,5,6,7,8, 9, 10,11,12,13, 14, 15,16,17,18, 19, 21	Save Our Bosque Task Force	Nyleen Stowe	1st year	Consolidate existing restoration and rehabilitation plans and biotic and abiotic information for the Rio Grande "active" floodplain from San Acacia to San Marcial; product will be a comprehensive conceptual restoration plan.
Outreach: $132,900							
O	Student Ecology Research Project	Middle Rio Grande	19	New Mexico Museum of Natural History and Science	Jeanne Lubbering	3rd year	Provide research education and experience for students from Bernalillo, Los Lunas, Belen, and Socorro high schools; training opportunities in aquatic and terrestrial ecology research techniques, design and implementation of long-term monitoring sites in each community. Several additional schools participated in FY2002.
O	Develop Educational Materials and Positive Relationships with Local Communities	Middle Rio Grande	4,9,10,12,15	U.S. Fish and Wildlife Service/ Sevilleta NWR	Deb Davies, Dawn Citrin	2nd year	Development and implementation of an educational curriculum that focuses on the importance of the cottonwood bosque/riverine habitat and ways in which community members can work toward enhancing, restoring, and saving the native riparian forests.
O	Private Land Conservation along the Middle Rio Grande to Enable Habitat Restoration	Middle Rio Grande	2,3,4,7,8,9,10, 13, 14,15,16,17,21	Taos Land Trust	Peter R. Bryant	1st year	Develop tools to educate landowners in the Middle Rio Grande about conservation easements and provide information on how conservation easements will enable habitat restoration in the floodplain.

Appendix B.9—FY2002 Middle Rio Grande Bosque Initiative Funded Projects--*Concluded*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
O	Bosque Education Guide Educator's Training/Support	Middle Rio Grande	All	Friends of the Rio Grande Nature Center State Park	Mary Stuever	1st year	Production of Bosque Education Guide Books and kits, training courses for 100 educators, and educator outreach via newsletter.
O,H	Restoring the Middle Rio Grande: A Community Action Plan--Next steps: Creation of a River Advocates Program and a Bosque Speaker's Bureau	Middle Rio Grande	Various	Rio Grande Restoration	Deb Hibbard	3rd year	Develop and implement a River Advocate training program to enable participants to become further informed about the river and to explore complex issues and action opportunities. Develop a Speaker's Bureau.
O,R	The Rio Grande Ecology Institute....at the Rio Grande Nature State Park	Rio Grande	11,12,19	Friends of the Rio Grande Nature Center State Park	Dr. Karen Brown, Rob Yaksich	3rd year	Four-week summer program designed for high school sophomores and juniors to study the biology, hydrology, water management, aquatic ecology and endangered species of the bosque.
O	The Rio Grande at Central Bridge: Historical and Today	City of Albuquerque/ Albuquerque Biological Park	--	City of Albuquerque/ Albuquerque Biological Park	Holly Casman	1st year	An educational exhibit will be constructed and displayed at the Albuquerque Aquarium. Two 750-gallon aquariums and corresponding informational graphic panels will present to the visiting public how the fish fauna of the Rio Grande has changed over the past 100 years due to the activities of man.
O,H	Santo Domingo River Restoration Project	Santo Domingo Pueblo	--	Santo Domingo Tribe	Margaret Chavez	1st year	Development of restoration program on Santo Domingo Pueblo.
Coordination: $110,000							
TOTAL: $1,048,000							

Appendix B.10—FY2003 Middle Rio Grande Bosque Initiative Funded Projects

[R, research; M, monitoring; O, outreach; H, habitat; --, no data.]

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
Research: $267,230							
R	Water Use by Middle Rio Grande Phreatophytes	Middle Rio Grande	3,17,18,19,21	University of New Mexico	Dr. James Cleverly	3rd year	Study to: determine annual evapotranspiration (ET) rates for native and non-native riparian plant communities; assess the effect of flooding on annual ET; evaluate inter-annual variability in ET; and contribute calibration parameters to the Middle Rio Grande water budget.
R	Restoration of Native Riparian Flora	Bosque del Apache National Wildlife Refuge	8,14,16,17,18, 19,21	Texas Tech University	Dr. Loren Smith John Taylor	3rd year	Research project to provide requisite knowledge to maximize native riparian flora recruitment on active river floodplain on controlled flooding areas outside the floodplain.
R,M,O	Bosque Hydrology Group, FLO-2D Workgroup	Middle Rio Grande	1,2,3,21,4,5,7, 8,15,16	U.S. Fish and Wildlife Service/ Water Resources Division	Paul Tashjian	8th year	Coordinate and synthesize hydrologic data within the Middle Rio Grande as they relate to the restoration of the bosque and maintain web page for information distribution. Coordinate Bosque Hydrology Group and FLO-2D Workgroup.
R	River Bar Vegetation Mapping: Extent and History in the Albuquerque Reach	Middle Rio Grande	2,4,7,15,16,17	University of New Mexico	Dr. Esteban Muldavin	2nd year	Development of a map of river bar vegetation in the Middle Rio Grande with an analysis of current bar configuration and extent in a historical context.
R, H	Middle Rio Grande FLO-2D Model Support	Middle Rio Grande		Tetra Tech, Inc.	Jim O'Brien	2nd year	Provide calibration and detailed model application of the Middle Rio Grande FLO-2D model that will be used to predict overbank flooding and floodwave attenuation on the Middle Rio Grande. Model results will aid in restoration planning.

Appendix B.10—FY2003 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
R	River Bar Biodiversity Studies: Aerial Insects, Vegetation Structure and Bird Habitat	Middle Rio Grande	4,7,15,16,17	University of New Mexico	Dr. Esteban Muldavin	1st year	Study will broaden the comparative biodiversity studies of river bars and bosque in the Middle Rio Grande to include aerial insects and vertical vegetation structure as important components of bird habitat.
R,H,O ,M	Jardines del Bosque Research Station: Urban Ecology on the Rio Grande, 2003	Rio Grande Bosque	4,5,7,8,9,11,12, 13,14,15,16,17, 18,19,20,21	National Hispanic Cultural Center of New Mexico	Carlos Vasquez	3rd year	Establishment of a Research Center located within the Cultural Center facility and adjacent 12-acre bosque site that will serve as an outdoor laboratory and study center for the community to learn and research the wild life and natural habitat of the bosque.
R	Habitat Requirements of the Southwestern Willow Flycatcher in the Middle Rio Grande Valley (Year 2)	Middle Rio Grande Valley	19	University of New Mexico	Dr. Pete Stacey	2nd year	Assess the habitat requirements of the southwestern willow flycatcher to better understand the endangered bird's nesting and territory selection process.
R,H,O	Methods for Restoring a Sustainable Mesic Grass and Herbaceous Component to the Middle Rio Grande Riparian Ecosystem	Bosque near Isleta Pueblo and Algodones, Rio Grande Nature Center State Park and Candelaria Wetland	Terrestrial resource recommendation	Friends of the Rio Grande Nature Center State Park	Doug Shaw	1st year	Mesic habitat associated with Bosque meadows offers specific habitat for wildlife. This study will develop methods for re-establishing mesic-grassland in the bosque.
R,M,H	Riparian Restoration of Abandoned Irrigated Farmland along the Middle Rio Grande	Polvadera	--	Ross Coleman	Ross Coleman	2nd year	Establish an experimental protocol for the riparian restoration of abandoned irrigated farmland and create a working model with associated wildlife and societal benefits.
Monitoring: $154,000							
M	Bosque Ecosystem Monitoring Program (BEMP): Science Section	Middle Rio Grande riparian forest/bosque	18, all indirectly	University of New Mexico	Dr. Cliff Crawford	6th year	Long term ecological monitoring using an outreach approach for participants to understand the changing dynamics of the Middle Rio Grande riparian forest.

Appendix B.10—FY2003 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
M,O	Monitoring Program & Outreach for the Conceptual Restoration Plan for the Rio Grande from San Acacia to San Marcial, NM	San Acacia to San Marcial	1,2,4,5,7,9,10, 11,13,14,15, 16,17,18,21	Save Our Bosque Task Force	Doug Boykin Gina Dello Russo	2nd year	Project will consolidate existing restoration and rehabilitation plans along with the existing biotic and abiotic information for the Rio Grande "active" floodplain reach from San Acacia to San Marcial, NM.
M	Bird and Vegetation Community Relationships - a 21-year comparison	Corrales south approximately 50 miles	18,8,12,16,19	Hawks Aloft, Inc.	Gail Garber	1st year	Comprehensive re-analysis/ assessment of avian abundance and richness relative to vegetation communities along the Middle Rio Grande compared to that found 21-years ago.
M	Restoration Monitoring of the Pueblo of Santa Ana Bosque Restoration	Pueblo of Santa Ana	2,8,14,15,16, 17,18	Pueblo of Santa Ana	Brian Bader	2nd year	Wildlife and vegetation monitoring program to assess changes associated with the Pueblo's bosque restoration efforts.
M	Monitoring Trends in the Breeding Populations of Raptors and Owls in the Middle Rio Grande Corridor (Year 2 Funding Request)	Corrales south to Bosque del Apache National Wildlife Refuge	18	Hawks Aloft, Inc.	Gail Garber	2nd year	Conduct a complete survey of the population of breeding raptors and owls to determine species composition and breeding pair density, monitor active nests for success, productivity, food habits, habitat characteristics, and disturbance factors.
Habitat Enhancement/Restoration: $273,649							
H	Save Our Bosque Task Force/Socorro County Bosque Rehabilitation/Protection Project	Socorro County	8,9,11,12,13, 14,16,17,18,19	Save Our Bosque Task Force	Doug Boykin	7th year	Exotic species control/fuels reduction in and around cottonwood and willow stands between San Acacia Dam and the north boundary of Bosque del Apache NWR using manual and mechanical treatment and individual herbicide application.

Appendix B.10—FY2003 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H,M	Saltcedar Control - NAWCA Area Phase II	Bosque del Apache National Wildlife Refuge	1,3,4,7,8,11,13, 14,15,17	U.S. Fish and Wildlife Service/ Bosque del Apache NWR	John Taylor	1st year	Restoration of 200 acres of degraded saltgrass meadow habitat will be improved through saltcedar control using a combination of methods utilizing herbicide/burn and mechanical control and subsequent surface and sub-surface water management to regenerate saltgrass vegetation.
H,O	Los Lunas River Park Project	Los Lunas	6,7,8,9,11,12, 13,14,16	Tree New Mexico, Inc.	Suzanne Probart	3rd year	Restoration and establishment of a mixed-use River Park area along the Rio Grande.
H	Restoration of the Pueblo de Cochiti Bosque	Pueblo de Cochiti	8,9,11,14,16	Pueblo de Cochiti	Jacob Pecos	3rd year	Restoration project to protect and rehabilitate the bosque enhancing the biodiversity and ecological resources within the boundaries of the Pueblo de Cochiti.***
H	Brush Removal and Fire Break Project	Sevilleta National Wildlife Refuge	17,13	U.S. Fish and Wildlife Service/ Sevilleta NWR	Dennis Prichard	3rd year	Removal of salt cedar growing along the Rio Grande and creation of fire breaks to help preserve the larger, mature cottonwoods in wetland area of Sevilleta NWR.
H	Friends of Rio Rancho Open Space, Inc. - Bosque Improvement Project	Rio Rancho Bosque, north beach area	2,4,7,8,11,16,17	Friends of Rio Rancho Open Space, Inc.	Ann Bagley	1st year	Remove non-native vegetation from the bosque within Rio Rancho and perpetuate growth of native habitat, flora, and fauna for approximately 150 acres (long term). This grant is for the initial phase and restoration of approximately 5 acres.

Appendix B.10—FY2003 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H	Bosque Rehabilitation	Albuquerque, New Mexico	--	City of Albuquerque	Paula Montoya	3rd year	Restore bosque sites through: fuel reduction, removal of non-native trees and jetty jacks; planting of native under-story species which are absent; restore and repair burned areas; monitoring of newly planted species; and maintenance of non-native vegetation. This grant will concentrate on the acreage affected by the Atrisco and Montano July 2003 fires.
H	Rio Grande Valley State Park Burned Area Revegetation	Albuquerque, New Mexico	--	NM State Forestry	Greg Fitch	1st year	Burned area seeding project on the 265 acres affected by the Atrisco and Montano July 2003 fires.
Outreach: $147,770							
O	Educators Training/Support for the Bosque Education Guide	Middle Rio Grande	All	Friends of the Rio Grande Nature Center State Park	Mary Stuever	2nd year	Production of the Bosque Education Guide and kits, training courses for educators, outreach to educators via a newsletter, and support of web page.
O	Bosque Ecosystem Monitoring Program (BEMP): Outreach Section	Middle Rio Grande	18, all indirectly	Bosque School	Dan Shaw	6th year	Provide citizens an opportunity to learn about the bosque ecosystem by participating in long-term monitoring of key ecological and hydrological variables.
O,R	The Rio Grande Ecology Institute….at the Rio Grande Nature Center State Park	Rio Grande	11,12,19	Friends of the Rio Grande Nature Center State Park	Dr. Karen Brown Rob Yaksich	4th year	Summer program designed for high school sophomores and juniors to study the biology, hydrology, water management, aquatic ecology and endangered species of the bosque.
O,H	Restoring the Middle Rio Grande: A Community Action Plan	Middle Rio Grande Valley	1,7,8,11,13, 14,16,17,20,21	Rio Grande Restoration	Deb Hibbard	4th year	Action Plan focuses on community education and outreach to inspire positive and effective action for the river, with an emphasis on communication, collaboration, and creative problem solving.

Appendix B.10—FY2003 Middle Rio Grande Bosque Initiative Funded Projects--*Concluded*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
O	Student Ecology Research Project	Middle Rio Grande	19	New Mexico Museum of Natural History and Science	Tim Aydelott	4th year	Provide research education and experience for 48-60 students from schools within the Middle Rio Grande. Project will provide training opportunities in aquatic and terrestrial ecology, research techniques, and design and implementation of long-term monitoring sites in each community.
O	The BIG Picture: A Quarterly Newsletter of the Middle Rio Grande Bosque Initiative	Middle Rio Grande	21	Kathleen A. Grassel	Kathleen Grassel	1st year	Design, research, write, and publish a comprehensive eight-page quarterly newsletter, reporting on MRGBI/BIG projects.
O	Santo Domingo Tribe Bosque Improvement Initiative	Santo Domingo Pueblo	--	Santo Domingo Tribe	Margaret Chavez	2nd year	Provide community education about the bosque (including native trees, habitat, wildlife, and river ecology) in order to promote a healthy ecosystem.
Coordination: $128,611							
TOTAL: $971,260							

***This project was funded with FY2002 funds.

Appendix B.11—FY2004 Middle Rio Grande Bosque Initiative Funded Projects

[R, research; M, monitoring; O, outreach; H, habitat; --, no data.]

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
Research: $145,000							
R	River Bar Vegetation Mapping: Belen to San Acacia	Middle Rio Grande -- Belen to San Acacia	2, 4, 7, 15, 16, 17	University of New Mexico	Esteban Muldavin, Elizabeth Milford	3rd year	Development of a map of river bar vegetation in the Middle Rio Grande with an analysis of current bar configuration and extent in a historical context.
R,H	Middle Rio Grand FLO-2D Model	Middle Rio Grande, Cochiti to San Acacia	1, 2, 3, 21	Tetra Tech Inc.	Jim O'Brien, Walt Kuhn	3rd year	Provide calibration and detailed model application of the Middle Rio Grande FLO-2D model that will be used to predict overbank flooding and floodwave attenuation on the Middle Rio Grande. Model results will aid in restoration planning.
R,M, O	Bosque Hydrology Group, FLO 2D Workgroup	Middle Rio Grande	1, 2, 3, 21, 4, 5, 7, 8, 15, 16	U.S. Fish and Wildlife Service/Water Resources Division	Paul Tashjian	9th year	Coordinate and synthesize hydrologic data within the Middle Rio Grande as they relate to the restoration of the bosque and maintain web page for information distribution. Coordinate Bosque Hydrology Group and FLO-2D Workgroup.
R	River Bar Biodiversity Studies: Aerial Insects, Vegetation Structure and Bird Habitat -- Part II	Albuquerque, NM	4, 7, 15, 16, 17	University of New Mexico	Esteban Muldavin, Elizabeth Milford, Cliff Crawford	2nd year	Study will broaden the comparative biodiversity studies of river bars and bosque in the Middle Rio Grande to include aerial insects and vertical vegetation structure as important components of bird habitat.
R,H, O,M	Jardines del Bosque Research Station: Urban Ecology on the Rio Grande	Middle Rio Grande	4,5,7,8,9,11,12, 13,14,15,16,17, 18,19,20,21	National Hispanic Cultural Center of New Mexico	Carlos Vasquez	4th year	Establishment of a Research Center located within the Cultural Center facility and adjacent 12-acre bosque site that will serve as an outdoor laboratory and study center for the community to learn and research the wildlife and natural habitat of the bosque.

Appendix B.11—FY2004 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
R	Habitat Requirements of the Southwestern Willow Flycatcher in the Middle Rio Grande Valley	Middle Rio Grande	19	University of New Mexico	Dr. Peter B. Stacey	3rd year	Assess the habitat requirements of the southwestern willow flycatcher to better understand the endangered bird's nesting and territory selection process.
Monitoring: $78,000							
M	Monitoring Trends in the Breeding Populations of Raptors and Owls in the Middle Rio Grande Corridor (Year 3 Funding Request)	Middle Rio Grande Corridor	18	Hawks Aloft, Inc.	Gail Garber	3rd year	Conduct a complete survey of the population of breeding raptors and owls to determine species composition and breeding pair density, monitor active nests for success, productivity, food habits, habitat characteristics, and disturbance factors.
M,O, H	Bosque Ecosystem Monitoring Program (BEMP): Science Section	Middle Rio Grande	18	University of New Mexico	Cliff Crawford	7th year	Long term ecological monitoring using an outreach approach for participants to understand the changing dynamics of the Middle Rio Grande riparian forest.
M	Bird and Vegetation Community Relationships: a 21-year comparison	Middle Rio Grande	18, 8, 12, 16, 19	Hawks Aloft, Inc.	Gail Garber	2nd year	Comprehensive reanalysis/assessment of avian abundance and rich-ness relative to vegetation communities along the Middle Rio Grande compared to that found 21-years ago.
Habitat Enhancement/Restoration: $142,000							
H,M, R	Saltcedar Control - NAWCA Area Phase III	Bosque del Apache NWR	7, 8, 9, 11, 13, 14,	U.S. Fish and Wildlife Service/Bosque del Apache NWR	John Taylor, Kirk C. McDaniel	2nd year	Continued restoration of 260 acres of xeric riparian habitat. Phase III includes shreading/multching of 130 acres of previously treated saltcedar.
H	Whitfield Migratory Wildlife Habitat Improvement	5 acres in Valencia County	1, 2, 8, 9, 15, 18	Valencia Sol and Water Conservation District	Dale A. Jones	1st year	Purchase of riparian flora to plant on restored wetland.

Appendix B.11—FY2004 Middle Rio Grande Bosque Initiative Funded Projects--*Continued*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
H	Bernardo Bosque Fire Rehabilitation Project	Bernardo, NM	look up	Middle Rio Grande Conservancy District	Sterling Grogan, Yasmeen Najmi	1st year	Rehabilitate a 75-acre burn area in the Bernardo Bosque. Project will include removal of hazardous dead and down wood and lowering fuel depths to prescription, maintenance of exotic tree re-growth, and revegetation with native understory plant species.
H	La Cienega Watershed Alliance Riparian Restoration	Southern end of La Cienega Watershed	21, 2, 5, 7, 11, 14, 15	Santa Fe Botanical Gardens	Linda Milbourn	1st year	Restore and protect the natural values of the wetlands and riparian system through removal of non-native trees, monitoring restored sites, evaluating need for planting of native trees, revegetating as necessary and providing opportunities for educational and public outreach about riparian restoration.
H,M, O	Update & Implementation Guide for the Bosque Biological Management Plan	Middle Rio Grande	20, 21, all	Rio Grande Restoration	Deb Hibbard, Jeremy Vesbach	3rd year	Development of an update and implementation plan that will supplement the BBMP (Crawford et al., 1993).
H	Save Our Bosque Task Force/Socorro County Bosque Rehabilitation/Protection Project	Socorro County	8, 9, 11, 12, 13, 14, 16, 17, 18, 19	Save Our Bosque Task Force	Doug Boykin	8th year	Exotic species control/fuels reduction in and around cottonwood and willow stands between San Acacia Dam and the north boundary of Bosque del Apache NWR using manual and mechanical treatment and individual herbicide application.
H	Los Lunas Riverpark Project	Los Lunas	7, 11, 12, 13, 14, 16	Tree New Mexico	Suzanne Probart, Drew Schuler	4th year	Restoration and establishment of a mixed-use River Park area along the Rio Grande.
Outreach: $71,000							
O	Bosque Ecosystem Monitoring Program (BEMP): Outreach Section	Middle Rio Grande	18	Bosque School	Dan Shaw, Cliff Crawford	7th year	Provide citizens an opportunity to learn about the bosque ecosystem by participating in long-term monitoring of key ecological and hydrological variables.

Appendix B.11—FY2004 Middle Rio Grande Bosque Initiative Funded Projects--*Cocluded*

Type	Project Title	Project Location	Applicable recommend-ations	Organization	Project Coordinator	Status	Project description
O	Educators Training/Support for the Bosque Education Guide	Middle Rio Grande	All	Friends of the Rio Grande Nature Center	Rebecca Tydings, M.A, Mary Dwyer, M.A.	3rd year	Production Bosque Education Guide production and kits, training courses for 200 educators, outreach to educators via a newsletter, and support of web page. Add addendum of fire activities (Spanish translation).
O	Pathways to Environmental Understanding	Pueblo de Cochiti	19	Mary Jo Daniel	Mary Jo Daniel, Dr. Peter B. Stacey	1st year	Six-week summer educational program that uses the Rio Grande Bosque as a context in which students can explore traditional indigenous sources of knowledge as well as modern Western scientific processes.
Coordination: $107,223							
TOTAL: $543,223							

Middle Rio Grande Ecosystem: Bosque Biological Management Plan

Recommendations 1993 -- 2004

[Detailed descriptions of Recommendations 1-21 are provided in the Middle Rio Grande Ecosystem: Bosque Biological Management Plan (Crawford et al., 2003). A description of Recommendation 22 is located in Part Three of this Update.]

RECOMMENDATION 1: Coordinate Rio Grande water management activities to support and improve the bosque's riverine and terrestrial habitats, with special emphasis on mimicking typical natural hydrographs.

RECOMMENDATION 2: Implement measures to allow fluvial processes to occur within the river channel and the adjacent bosque to the extent possible.

RECOMMENDATION 3: Reintroduce the dynamics of surface-water/groundwater exchange, manage groundwater withdrawal, and restrict contamination.

RECOMMENDATION 4: Protect, extend, and enhance the structure of aquatic habitat to the benefit of native communities.

RECOMMENDATION 5: Protect and enhance surface water quality.

RECOMMENDATION 6: Integrate management of nonnative and native fish species in all aquatic environments in the Middle Rio Grande riparian ecosystem including wetlands, canals, and drains.

RECOMMENDATION 7: Protect the geographic extent of the Rio Grande bosque and avoid further fragmentation of the riparian ecosystem and component habitats.

RECOMMENDATION 8: Protect, extend, and enhance riparian vegetation in noncontiguous areas in the floodplain.

RECOMMENDATION 9: Manage the buffer zone of the contiguous bosque to protect ecosystem processes, enhance wildlife habitat values, and maintain rural and semi rural conditions.

RECOMMENDATION 10: Manage livestock grazing in a manner compatible with biological quality and ecosystem integrity.

RECOMMENDATION 11: Manage activities that remove dead wood in a manner compatible with biological quality and ecosystem integrity.

RECOMMENDATION 12: Manage recreational activities in the bosque in a manner compatible with biological quality and ecosystem integrity.

RECOMMENDATION 13: Prevent unmanaged fires in all reaches of the bosque.

RECOMMENDATION 14: Use native plant species and local genetic stock in vegetation establishment and management efforts throughout the bosque.

RECOMMENDATION 15: Protect, enhance, and extend (create) wetlands throughout the Middle Rio Grande riparian zone.

RECOMMENDATION 16: Sustain and enhance existing cottonwood communities, and create new native cottonwood communities wherever possible throughout the Middle Rio Grande riparian zone.

RECOMMENDATION 17: Contain the expansion of existing large stands of nonnative vegetation in the Middle Rio Grande riparian zone. At the same time, study the ecology of these stands and develop creative ways of maximizing their biological values.

RECOMMENDATION 18: Develop a coordinated program to monitor biological quality (with emphasis on the diversity and abundance of native species) and ecosystem integrity (with emphasis on restoring the functional connection between the river and riparian zone) of the Middle Rio Grande ecosystem.

RECOMMENDATION 19: Develop a coordinated research program to study the ecological processes and biotic communities that characterize the Middle Rio Grande riparian ecosystem.

RECOMMENDATION 20: Regularly review and update the Middle Rio Grande Ecosystem: Bosque Biological Management Plan.

RECOMMENDATION 21: Integrate resources management activities along the Rio Grande and within the contributing watersheds to protect and enhance biological quality and ecosystem integrity.

RECOMMENDATION 22: Develop outreach initiatives through public education programs and events, and community participation activities and projects, to broaden public understanding of and generate more active interest in bosque restoration and river ecosystem management in the Middle Rio Grande.