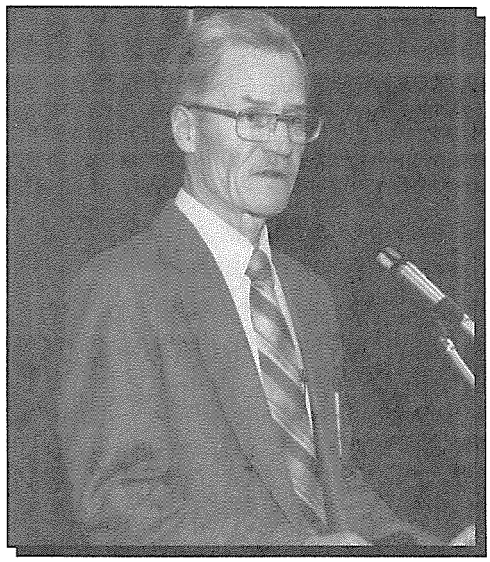
Clifford Crawford is now a research professor of Biology at UNM having recently retired after a long career on the UNM faculty. In 1993, he led the interagency team that produced the Middle Rio Grande Ecosystem: Bosque Biological Management Plan. Over the past decade, Cliff's research emphasis has shifted from desert invertebrate biology to a collaboration with his UNM colleague, Manuel Molles, on a study of riparian ecology along a gradient of mesic to arid regions. Cliff and Manuel teach a nearly continuous course, "Bosque Biology," and since 1991 have conducted a manipulative flooding project supported by the U.S. Fish and Wildlife Service, at Bosque del Apache National Wildlife Refuge.



FLOODING AND CONSERVATION IN THE ALBUQUERQUE BOSQUE

Clifford S. Crawford
Manuel C. Molles, Jr.
and
H. Maurice Valett
Department of Biology
University of New Mexico
Albuquerque, NM 87131

INTRODUCTION

Interest in the conservation of the Middle Rio Grande bosque has grown rapidly in the last decade. During that period, private organizations as well as governmental agencies have sharpened their focus on the issue (Nunn 1994), and in doing so have contributed to the development of a bosque biological management plan for the river reach between Cochiti Dam and Elephant Butte Reservoir (Crawford et al. 1993). This increased regional attention reflects a growing national and international concern about human impacts on fluvial processes in large floodplain rivers. In recent decades especially, such impacts have often caused irreversible changes in the ecological functioning (i.e., loss of "ecological integrity") of these river systems (National Research Council 1992).

Because they impound large amounts of a river's discharge and interfere with its natural flooding regime, dams can seriously disrupt the relationship between river basin hydrology and riparian zone functioning (Boon 1992). In western North America, this interference reduces cottonwood germination and survival (Rood and Mahoney 1990) and, as will be discussed below, negatively affects key ecological processes in riparian communities.

In this paper we first review how the decoupling of basin hydrology from riparian forest processes has begun to affect the integrity

of the Middle Rio Grande bosque ecosystem. Then we propose an alternative management scheme, with emphasis on the Albuquerque bosque, that centers on restoring its ecosystem functioning.

ECO-HYDROLOGY OF THE BOSQUE PAST

During its existence as a distinct river, the pre-settlement Rio Grande must have moved back and forth across its floodplain. From time to time, flooding runoff from late spring snowmelt would have triggered abrupt closures of old channels and created new ones. As this happened, riparian forest stands owing their existence to earlier spring floods would have been variously impacted. Stands near new channels would have continued to benefit from periodic overflows bearing nutrient-laden silt. Simultaneous wetting of the soil column beneath these stands would have activated the decomposition of accumulated litter and the cycling of mineralized nutrients.

Between such older, well-nurtured stands and the river bank, rows of new cottonwoods and willows planted by more recent floods would have eventually produced an uneven-aged forest of some depth. In contrast, older stands left stranded by the river's shift would have been increasingly isolated from its nutrient-yielding influence as they declined with age. Only root suckering, which occurs throughout the Middle Rio Grande bosque, would have created new trees in their vicinity. Figure 1 illustrates this composite pre-settlement scenario and contrasts it, in the region of present-day Albuquerque, with the current, constrained and straightened river channel lined by a continuous thin strip of riparian forest.

For the most part, the pre-settlement Middle Rio Grande would have meandered more than it does now, and in places would have formed oxbow marshes and other wetlands as it changed course. Wetlands such as lakes, ponds and wet meadows would have gone through their successional cycles during years and decades of relatively high flows and high water tables. During times of drought, however, many of these wetlands may have dried up, and when the water table dropped appreciably during severe droughts, many cottonwood stands would have died. Thus a climate-related ebb and flow of life, mediated by the basin's hydrology, was undoubtedly integral to the evolution of the Middle Rio Grande bosque, and to its unique structure and functioning as an ecotonal interface (e.g., Gosz 1993) between terrestrial and riverine systems.

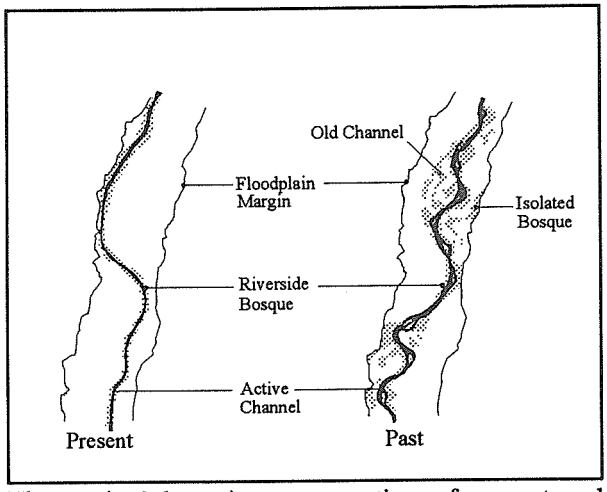


Figure 1. Schematic representation of present and imagined past configuration of the Rio Grande and its bosque through the central Albuquerque area.

FLOOD CONTROL AND REGULATED FLOWS IN THE MIDDLE RIO GRANDE

As humans settled the Middle Rio Grande Valley they naturally began to utilize its resources. The story of their progressive use of these resources and the environmental consequences of that use is documented elsewhere (e.g., deBuys 1985, Scurlock 1988, Crawford et al. 1993). Here we simply point out that by the 20th century there was a strongly perceived need by valley inhabitants for flood control, drainage, and continued irrigation.

While irrigation changed the way water flowed through the valley, it probably had little impact on the bosque or on wetlands. Flood control and drainage, however, had clear impacts. Flood control involved construction of levees and dams. In combination, these greatly reduced both the potential for cottonwood-willow recruitment on exposed silt banks and bars, and the potential for nutrient cycling within existing stands.

By the 1930s, erosion and deposition of sediments along the Rio Grande near Albuquerque had raised the river bed, produced outward flows of groundwater and elevated the water table in the floodplain. This created problems for agricultural land use bordering the river at the time. Drainage systems were quickly constructed, and these had a dramatic effect on floodplain wetlands. In a matter of a few years most valley wetlands disappeared (Van Cleave 1935). Between 1935 and 1989 in the Albuquerque and Belen reaches, wetlands declined by more than 80 percent (Crawford et al. 1993).

PARTIAL RESTORATION: AN ALTERNATIVE APPROACH

Conservation of highly altered river systems such as the Middle 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 re-establishment of basic riverine-riparian functioning, rather than the "saving" of a bosque that is itself an artifact of civilization. In effect, 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 in keeping with the more inclusive recommendations of the "Middle Rio Grande Ecosystem: Bosque Biological Management Plan" (Crawford et al. 1993). The essential elements 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.

This prescription accepts a certain amount of structural change in the bosque as inevitable, but insists on the maintenance of a system that to some degree acts like that of old. Key to our proposal is the need to allow the river channel to move laterally (where politically possible) from its present confined channel. Clearly this can be accomplished more easily in some reaches than in others. In most of the Albuquerque Reach, lateral movement is probably not possible.

The rationale for overbank flooding is alluded to above; it enables cottonwood and willow seeds to become established if flooding is timed correctly, and it promotes a healthy, relatively litter-free stand of native riparian trees. Without going into detail in this non-technical report, the results of our ongoing research at Bosque del Apache National Wildlife Refuge demonstrate that when a cottonwood stand deprived of flooding for half a century is experimentally flooded, a series of ecological processes associated with decomposition and nutrient cycling is once again initiated (Ellis et al. 1993, Ellis et al. 1994, Lieurance et al. in press, Molles et al. in press).

More time to continue this manipulation, and to compare manipulation results with simultaneous observations in a regularly flooded stand is required before we can translate our findings into cost-benefit assessments for partial restoration of specific sites along the river. Different sites will no doubt require different levels of inundation. We feel it is important for managing agencies to begin to identify areas where partial restoration has potential.

One pertinent fact is already clear: an unflooded bosque accumulates considerable amounts of undecomposed leaf and woody litter. This material becomes fuel for fires that increasingly occur—nearly always because of human activity—during the dry and windy spring months along the Middle Rio Grande (Mary Stuever, personal communication, 1994). Although poorly studied in central New Mexico, southwestern cottonwoods and willows appear to lack efficient post-fire resprouting mechanisms (Busch and Smith 1993). Initial unpublished results from our research at Bosque del Apache reveal the importance of flood-induced decomposition in reducing the forest floor fuel load.

Management of the bosque in order to promote habitat diversity is beyond the scope of

this paper, as is a detailed discussion of the need for monitoring, research, and education. We feel obliged, however, to address the last of our four points, namely the issue of wetland creation. Wetlands are associated with flooding because while they can be produced by inundation, they can also "buffer" flood events by taking up water that would otherwise flow freely down the main channel or across the floodplain. Also, besides adding significantly to the biological and landscape diversity of a region, wetlands can be sheltering, nutrient-rich habitats for the early stages of native fish species (Kwak 1988, Turner et al. 1994). Finally, wetlands, like riparian forests, can act as buffers that maintain river water quality by intercepting agricultural and industrial runoff and by transforming pollutants such as nitrates and phosphates into biologically useful compounds or harmless gasses (Pinay and Decamps 1988).

BOSQUE CONSERVATION GOALS

In his keynote address at the 1994 New Mexico Riparian Conference, William deBuys stressed the importance of a "sense of ownership" of the bosque by residents of the Rio Grande valley. Use of the term, "ownership," was intended by deBuys to mean a "loyalty to place." Without such loyalty, conservation of the bosque is apt to be carried out by independently acting agencies operating according to their own mandates. Fortunately, in recent years the idea of open, coordinated management of the bosque has received strong public support, especially in Albuquerque. The Bosque Action Plan for the Rio Grande Valley State Park is tangible evidence of how municipal and state agencies can work with an enlightened citizenry to establish a section of riparian forest that can be simultaneously enjoyed and conserved.

However, the Albuquerque public will be ill-informed if it does not realize that the integrity of its bosque will eventually collapse if some form of periodic inundation is not provided, and/or if levels of shallow groundwater are allowed to decline below depth thresholds of native trees. Both are realistic scenarios within the next 50 years, by which time the existing trees will be nearing the ends of their natural life spans.

The same problems apply in varying degrees to other reaches of the Middle Rio Grande. Local solutions to these problems are possible, but need to be placed in the larger context. Indeed, the Albuquerque bosque is but a small segment of a long and greatly changed river system that drains an extensive river basin. No one part of the system can be managed in total isolation.

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