

The potential for implementing partial restoration of the Middle Rio Grande ecosystem

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Abstract.-The Rio Grande currently inundates only a small portion of its riparian forests during late spring runoff. Such flood events were once responsible for the germination of cottonwoods and willows along the river, for a mosaic of wetlands mixed with different aged stands of forest, and for enhancement of decomposition and nutrient cycling. River regulation in this century has decoupled the linkage between the floodplain and the river and has led to senescence without replacement of the once dominant native cottonwoods in the Middle Rio Grande (MRG) valley. We propose that partial restoration can be accomplished by re-establishing a regime of seasonal wetting of riparian soils at select sites most likely in the MRG's southern reach. Our research at Bosque del Apache National Wildlife Refuge suggests that this practice would 1) accelerate decomposition and nutrient cycling within existing stands and 2) promote cottonwood-willow germination on banks and other cleared areas. It could also expedite the creation of wetlands. We outline methods of implementing partial restoration, and emphasize the importance of continuous monitoring by citizen volunteers. With careful planning and implementation, our suggested approaches could be used for other restoration projects in the Rio Grande Basin.

INTRODUCTION: THE NEED FOR RESTORATION

From the time of its origin as a complete river system until regulation constrained its flows in this century, the Rio Grande has inundated its riparian forests, or "bosques," during late spring runoff. Such overbank flooding allowed cottonwood and willow germination along the river, supported a mosaic of wetlands mixed with forest patches of different ages, and enhanced decomposition and nutrient cycling within the forest. Now, due to extensive water management, such flood events are rare and occur only in limited areas where accumulated sediments raise the river bed high enough to allow overbank flow into the riparian zone.

The floodplain has changed greatly in the absence of annual flooding. The once-meandering river lies straightened between levees, and germination of cottonwood seeds on flood-scoured banks has all but stopped. The old mosaic of wetlands and different-aged stands of cottonwoods and willows has been replaced by a nearly wetland-free floodplain, with discontinuous stands of declining cottonwoods which face severe competition from introduced woody species. Further, the cycle of decomposition and nutrient release that once sustained the riverside forests has lost its historic vigor.

The Middle Rio Grande (MRG) runs between Cochiti Dam and Elephant Butte Reservoir and has had a long history of use. Its water has been diverted for irrigation since the days of the early pueblos. Allocation of the diverted water became a major concern to floodplain inhabitants, and eventually resulted in a complex arrangement of water rights (Shupe and Folk-Williams 1988,

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Bokum et al. 1992) that may potentially restrict future flood-related restoration in most reaches. Interstate compacts in the early 1900s assured regional water delivery facilitated by channel widening and straightening (Bullard and Wells 1992). In the present century, flood control and drainage have profoundly altered the hydrologic character of both the river and its valley. The flow of impounded water between Cochiti and Elephant Butte is kept lower than most overbank flooding requires. Drainage produced the valley's dramatic loss of wetlands in the 1930s (Van Cleave 1935).

Urban development has played an important role in changes undergone by the MRG ecosystem. Many of the cottonwood stands so admired by Albuquerque residents were "planted" in 1941 by the last great flood before the construction of Cochiti Dam. Now, in the absence of flooding, leaves and woody debris accumulate and decompose slowly on the forest floor where they contribute to a growing fuel load (Molles et al. in press). Bosque fires are on the increase, and humans appear to be causing most of them (M. Stuever, unpublished data).

As the cottonwoods age without effective replacement in kind, expanding stands of Russian olive, salt cedar and other introduced woody and herbaceous plant species are altering the community structure of the MRG riparian zone (Campbell and Dick-Peddie 1964, Hink and Omart 1984, Howe and Knopf 1991, Durkin et al. 1995). The aquatic community, too, is experiencing pronounced change: its mostly extirpated fish fauna is being replaced by introduced species (Platania 1995). To continuous human residents of the valley these changes may seem imperceptibly slow or even nonexistent, but in the context of history they are rapid and reflect the ecological instability, or declining "ecological integrity," of the ecosystem.

Given the magnitude of the valley's transformation, the notion of anything even approaching complete restoration of the MRG ecosystem is unrealistic. However, we contend that parts of the system can be made to function as they did before regulation intervened. Our recent studies of ecosystem-level responses to seasonal inundation, together with background information from a variety of sources, suggest that partial restoration of judiciously selected sites along certain reaches is entirely possible.

In the following pages we first describe the research-based background for this viewpoint, and then consider how and under what circumstances partial restoration could be accomplished. Our rationale for doing this in central New Mexico is hardly unique. A growing interest in the restoration of large floodplain rivers and their riparian zones exists in many parts of the world (e.g. Boon et al. 1992, National Research Council 1992, Hesse et al. 1993; Sparks 1995). While both the concept and the implementation of environmental restoration face social (Vitousek 1994), political (Pastor 1995) and technical (Kondolf 1995) challenges, ignoring the condition of these recently degraded ecosystems only hastens their continuing deterioration. The ultimate losers include the humans who use them, suggesting that it is better to initiate restoration sooner than later.

RESTORATION-RELATED RESEARCH AT BOSQUE DEL APACHE

The ecological basis for partial restoration of the MRG is formally justified in the recommendations of a comprehensive biological management plan (Crawford et al. 1993). Several interacting groups of scientists and resource managers are currently working to develop this foundation. Among them is our team at the University of New Mexico, which is studying the effects of annual flooding on the Middle Rio Grande riparian forest. Our research at Bosque del Apache National Wildlife Refuge began in the late spring of 1991.

For the first two years of the study, we systematically measured a combination of physical (soil, water, meteorological) and biological (population, community, ecosystem) variables in two forest sites isolated from flooding for about 50 years. Site descriptions are given in Ellis et al. (1993, 1994, 1995). Starting in 1993 and using a combination of drain and irrigation water, we began to experimentally flood one of the sites each year between mid-May and mid-June, the period of maximum snow-melt runoff over the past 100 years. The other site, which continues to be monitored in the same way as the flooded forest, is our reference or control site.

In 1994, we established another pair of flood and control sites, this time in a nearby forest strip between the Rio Grande and the levee to its west

(the “river flood” and “river control” sites). Most of this forest is flooded when river flows exceed **4500** cfs; this typically occurs during spring runoff and when heavy summer storms flush tributaries to the north. A groin dike diverts water from one stretch of forest, providing the non-flooded control site. The same variables are monitored at both sets of sites.

Our detailed research results are **given** in a number of internal reports (Ellis et al. 1993, 1994, 1995) and external peer-reviewed publications (Lieurance et al. 1994, Molles et al. in press). Overall, floods in the isolated forest were characterized by slow-moving water and extremely anaerobic conditions at the soil-litter interface. Month-long flooding during two subsequent years at the isolated site saturated the soil column with water rendered anoxic by respiratory activity on the forest floor and in the saturated rooting zone. Flooding also deposited considerable silt; mobilized nitrogen; promoted high levels of forest floor respiration; and enhanced litter decomposition, decomposer microorganism activity, native cricket activity, root mycorrhizal activity, and growth of large cottonwoods. In contrast, flooding inhibited litterfall, forb growth and ant diversity and activity, and it decreased activity of introduced isopods. (Crickets and isopods consume dead organic material; ants are omnivores and soil movers.) There has been no detectable change in rodent populations.

Meanwhile, the flood at the river site consisted of moving water (averaging approximately 10 cm/sec) that contributed to different conditions on the forest floor. Water at the soil-litter interface remained well oxygenated (never less than 3 ppm dissolved oxygen), reflecting lower litter storage and the influence of moving water. Inundation lasted for two-and-a-half months in the late spring and summer of 1995, with highly oxygenated surface water and deeper anoxic groundwater generally separated. We believe that separation of surface floodwater and groundwater resulted from an impervious layer of silt and clay contributed largely by the Rio Puerco upstream from our study site. Our data show that significantly more silt was deposited in this forest during 1994 and 1995 than was deposited in the experimental forest.

Data on nitrogen fluxes, litter decomposition, mycorrhizal activity, and cottonwood growth are

not yet available. However, we do know that forest floor respiration at the river flood site was lower than in the isolated experimental forest, but was much higher than respiration rates in both the control sites that remained unflooded. **In** addition, litterfall at the river flood site in 1994-95 was significantly greater than in **the** isolated forest. Crickets appeared to be the **most** active detritus consumers at the river flood site, while only **one** arboreal species of ant was **common** there. The near-absence of herbaceous understory vegetation in the flooded river forest is striking; this is true also of forest-floor leaf litter which, following prolonged flooding, was both washed away and buried by silt. The size-frequency curve of cottonwoods in the river flood site has a significantly greater median value than that of cottonwoods in the isolated sites. Rodents (entirely *Peromyscus leucopus*) are more abundant at the river flood site compared to the river control, suggesting a positive response by mice to flooding.

A MODEL OF THE EFFECTS OF FLOODING AN ISOLATED BOSQUE

Based on our research at Bosque del Apache, we have begun to propose a conceptual model of how an isolated riparian forest **can** become partially restored in the Middle Rio Grande ecosystem. According to the model, such a forest is initially in a “**disconnected phase**”, reflecting its isolation from overbank inundation. Our research indicates that when an isolated forest is artificially flooded, the externally supplied water triggers what we call a “reorganization phase,” immediately characterized by distinct changes in ecological processes and biological populations. Riparian forests regularly flooded by rising water during late spring runoff are, in our view, in a “steady state phase.” Although the ecological processes and biological populations of forests in this phase undergo seasonal changes in amplitude, the changes are relatively slight from year to year.

INITIATING AND IMPLEMENTING PARTIAL RESTORATION

The Middle Rio Grande no longer shifts its course within the floodplain, and many of the

plants and animals in its riparian bosques are introduced. Complete restoration to pre-alteration conditions is therefore no longer feasible. However, by applying the knowledge gained from past and current studies, we contend that restoration of function (although not entirely of structure) can be achieved in selected units of the MRG ecosystem.

The goal of such partial restoration should be to establish and maintain a mosaic of riparian forest stands that can be accessed and flooded with relative ease. Ideally, restoration sites should be strung along all reaches of the river. However, political reality dictates otherwise in central New Mexico. Due to land ownership and control along the Rio Grande, and because the degraded northern river bed for the most part precludes overbank flooding, initial restoration efforts should focus on areas south of Belen. Expansive tracts between Bosque del Apache and Elephant Butte appear to have potential, even though now covered by salt cedar. Although total eradication of salt cedar is no longer considered viable, mechanical removal is routinely performed by Bosque del Apache personnel. Moreover, this exotic species can be managed as a minor component of the ecosystem, as recommended in the MRG bosque biological management plan (Crawford et al. 1993), and various studies (e.g., Ellis 1995; Ellis et al. 1995) have shown its biotic diversity to be unexpectedly high.

Partial restoration should emphasize two different types of sites. One is typified by the isolated forest we study at Bosque del Apache. An applied flooding regime at such a site should, according to our initial calculations, lead to a steady state within two to three decades. To achieve that state, water usually will have to be supplied during the runoff season either from the river or from ditches. Groundwater pumping is another alternative, and might be useful if the hard-to-flood northern sites are considered. Whichever method is used, inundation must occur annually in the late spring. Flooding this type of site will enhance the ecological integrity of the established forest, but will not promote recruitment of new cottonwood seedlings since the dense shade of older trees inhibits the growth and survival of newly germinated seedlings (Howe and Knopf 1991).

The other type of site is typified by silt bars and treeless river banks. Such places can be used to create new riparian forests via the germination of flood-planted cottonwood and willow seedlings (e.g. Stromberg et al. 1993). To be usable, the sites should have porous soils and little plant cover, conditions that can be generated by mechanical removal of existing vegetation and/or by previous flood water scouring. John Taylor and his colleagues at Bosque del Apache have had success with a combination of these treatments on the

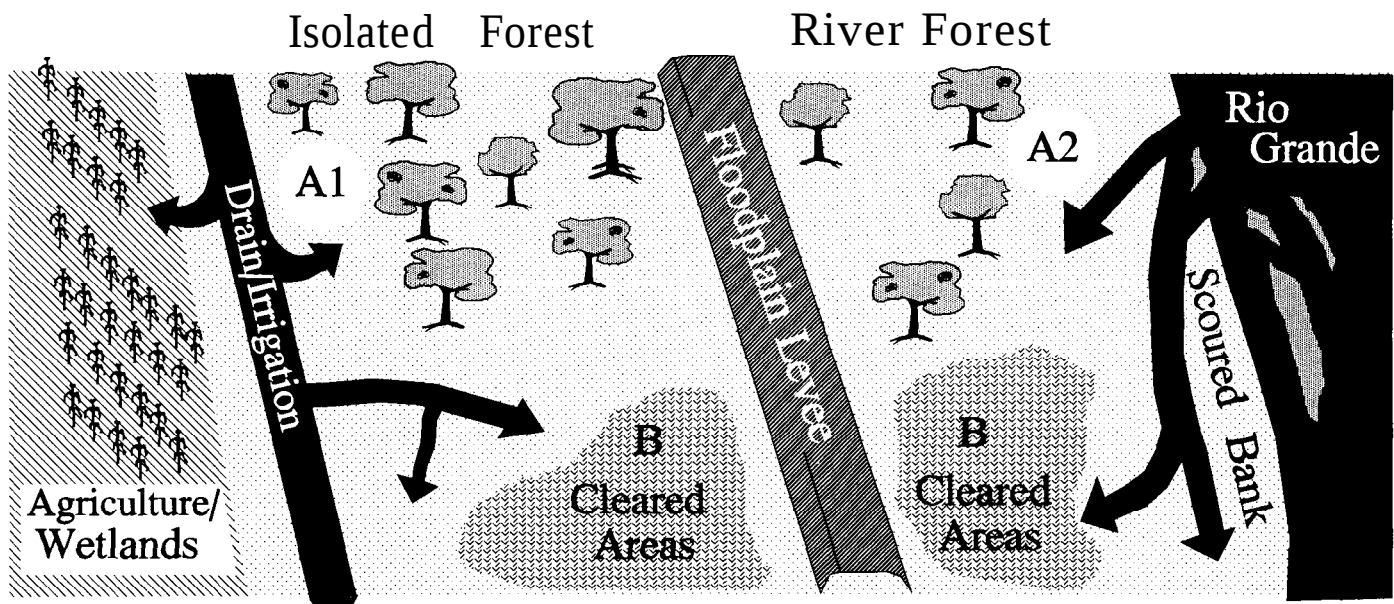


Figure 1. Potential alternative sites suitable for bosque restoration. A1 □ forest restoration, A2 □ forest maintenance, B = forest creation.

Refuge's west river bank. They have also shown that cleared floodplain distant from the river can produce cottonwood and willow stands as long as the soil is thoroughly wetted when windblown seeds are dispersing (i.e., during peak runoff). Simultaneous germination of tiny salt cedar seeds can be a problem in either case, but if the cottonwood seedlings get a rapid start they compete well (A. Sher, personal communication). Figure 1 shows a schematic indicating the types of sites suitable for partial restoration.

While the first type of site requires repeated flooding, in the second type a single flood can produce highly visible effects. However, although additional late spring floods can add still newer recruits and may nourish existing stands, it should be cautioned that severe flooding can wash out stands of seedlings as well as larger trees.

It should be possible to use both approaches to create a mosaic of different-aged stands. The design of a site where this is planned will obviously require careful study before any treatment is applied. Distances from flowing water, depths to groundwater, permeability of soil, topographic features and soil salinity all should be documented at the initiation of study. Knowing soil salinity is essential since cottonwood germination is not effective in very saline soils (Sheets et al. 1994). For sites where cottonwood can germinate, it will also be necessary to ensure that post-flooding draw-down proceeds at a rate commensurate with the ability of seedlings to send roots downward. Desirable rates of soil drying are discussed in Mahoney and Rood (1991) and Scott et al. (1993).

CONCLUSIONS

While we are confident that partial restoration of the riparian forest can be achieved on selected units of the lower MRG, we realize that a long-term commitment is essential for success. Hence an interagency structure must exist to assure the continuous monitoring of sites undergoing restoration. Monitoring is necessary to know when corrective action is needed and to determine how long-lived organisms such as cottonwoods respond to management actions.

Deciding which variables to monitor will require the combined experience of researchers and

resource managers who work in the MRG ecosystem, as well as the expertise of others working in other riverine and riparian systems. Monitoring requires personnel; fortunately, there is a large pool of interested citizens in the valley eager to participate in monitoring. Their involvement would greatly reduce operational costs as well as create a sense of "stewardship" by the citizens of the valley. Funding for the effort should be carefully discussed in advance and solicited from private as well as public sources. A variety of local and regional institutions and industries have a stake in the future of the MRG; convincing them of this is essential. The monitoring operation should be socially and politically defensible as well as cost-effective, well coordinated and well publicized. Educating people about the project should take place at many levels, from young school children through top executives and politicians. The value of ecosystem restoration needs to be understood and accepted by the public as non-threatening and essential to our own well-being.

Successful partial restoration of selected units of the highly visible MRG bosque ecosystem could, if carefully designed and implemented, serve as a standard for other restoration projects in the Rio Grande Basin, and perhaps in other river basins as well. Regularly flooded riparian forests are themselves wetlands (Bayley 1995), but the application of water to the floodplain should also facilitate the re-establishment of marshes and ponds. Momentum is growing for the sustained functioning of once pristine river ecosystems. We think the momentum should include the Middle Rio Grande.

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