BOSQUE LANDSCAPE ALTERATION WILL REDUCE FIRES AND CONSERVE WATER: A PROPOSAL

Cliff Crawford
Department of Biology, The University of New Mexico
Albuquerque, NM 87131

Sterling Grogan
Middle Rio Grande Conservancy District
Albuquerque, NM 87102

Introduction

This proposal is intended as a point of departure for discussion and debate by those concerned with the management of fire and water in the Rio Grande's riparian forest, the bosque. The concepts we present here may seem radical at first, but they have been evolving for a decade or more (e.g. Crawford et al. 1993, 1994; also personal communications from Paul Tashjian and other members of the Bosque Hydrology Group). Specifically, our prescription for bosque landscape alteration centers on re-creating a patchy mosaic of native riparian trees and open spaces along the narrow active floodplain of the Middle Rio Grande. Although the present straightened and levee-bordered river will require that the mosaic be somewhat linear, it will otherwise resemble the pattern of scattered cottonwood groves interspersed by open spaces that once characterized the wider historic floodplain (Horgan 1984).

We present this picture in more detail below. In essence, it amounts to a restoration of the Rio Grande's riparian zone between the levees -- an action that will both diminish the potential for frequent and intense bosque wildfires and reduce water loss due to evapotranspiration (ET). The operation will involve the removal of most of the bosque's invasive trees, and some senescent native species as well. It will also create savanna-like woodland patches that can retain or be planted with an understory of native grasses and shrubs. Open areas between the patches will also support grasses and shrubs, and perhaps small numbers of widely spaced individual trees or groves useful for animals moving between the patchy woodlands. This combination of tree reduction and increased open space will reduce overall ET in the altered landscape and increase water in its shallow aquifer.

Landscape manipulations will be carefully monitored and evaluated before, during, and following the proposed bosque transformation. Carefully supervised citizen volunteers will be used as much as possible in all phases of the operation.

Background

Naturally occurring overbank floods were responsible for the historic establishment, maintenance, and at times the destruction of the Rio Grande's riparian forests. In the past

half-century, however, wildfires have begun to replace floods as the driving force behind the changing bosque's organization and appearance. The fires were and are still caused mostly by humans. Since the great floods of the early 1940s the effects of bosque fires have been intensified by the spread of invasive woody species and the accumulation of fallen and standing dead wood -- all during a period when peak flows were being progressively reduced by river regulation (Stuever et al. 1997).

Prior to regulation, the Rio Grande's flow regime was controlled by regional climate, basin geology, and floodplain geomorphology. The combined influence of these features was especially evident in the early growing season, when melting winter snows in the basin's upper watersheds produced a swollen river that often overflowed its banks. Those floods coincided with the release of wind blown cottonwood and willow seeds. They also prepared scoured banks for eventual seedling germination, and brought on avulsion events leading to new channel formation that in turn left trees on abandoned banks lacking significant hydrologic connectivity with the river (Crawford et al. 1994, 1996). Depending on the distance and elevation change between the new and old channels, average water table depths at the abandoned banks would at times have been well below their previous levels. Trees on those banks would then have been at risk, as water table depths exceeding ~3 meters result in cottonwood and willow water stress and eventual canopy dieback (Horton et al. 2001). Also impacted would have been seedling recruitment and nutrient uptake when soils beneath and around abandoned stands remained dry during the growing season.

Because of the apparent climatic uncertainty of the Holocene in what is now the U.S. Southwest (Graf 1994, Pearse and Kelson 2003), we speculate that the above scenario would have characterized a floodplain in which cottonwood and willow stands differed markedly in size, configuration, age, and health. We also assume that open spaces varying in size in the floodplain would have supported dryland grasses and shrubs as they do now -- for example, in power line clearings. In other words, the riparian landscape on the whole would have been structurally complex, with an extensive diversity of habitats and species.

Compare such a picture with today's Middle Rio Grande riparian zone. The two are strikingly different. Following the entry of large numbers of humans into the valley, the old cottonwood groves were progressively cleared for agriculture and dwellings, or subjected to various forms of disturbance such as livestock foraging. By the mid-1800s beaver extirpation in the basin's upper watersheds led to the disrepair of their dams and subsequent soil erosion by heavy summer rains (Findley 1987). Heavy grazing and lumbering in the watersheds later in the century also added sediment to the river downstream (Wozniak 1995), raising its bed and causing severe flooding and eventual salinity problems in farm fields, as well as much damage to human communities (Scurlock 1998).

Pressures to make the floodplain more livable inevitably mounted and resulted in the formation of the Middle Rio Grande Conservancy District in 1925 (Scurlock 1998). The MRGCD, in cooperation with the U.S. Bureau of Reclamation and the U.S. Army Corps

of Engineers, drained the floodplain, improved irrigation, and instituted flood controls. By late century, river damming and other forms of flow regulation had reduced peak discharges to the point where overbank flooding had become rare in a river now greatly straightened, and positioned by levees. Within that new "active floodplain," stands of the no longer discontinuous bosque were then invaded by extensive spreads of invasive saltcedar, Russian olive, Siberian elm, and a variety of lesser species (Crawford et al. 1993). Competing with aging and infrequently reproducing cottonwood and willow trees for diminished water and flood-deposited nutrients, the invaders contributed enormously to the densely wooded, linear gallery stucture of today's bosque.

The crowded riparian forest's increasing use of water is bad news not only for the native bosque trees, but also for the inhabitants of rural and municipal communities in the middle valley. Meanwhile, New Mexico's southern Rio Grande valley, the states of Colorado and Texas, and the country of Mexico also have well-established claims to Rio Grande water. This combination of pressures, together with the present-day reduction of river discharge and a bosque becoming ever more vulnerable to wildfire, symbolizes the gravity of an issue that needs to be understood and faced realistically by the basin's rapidly growing human population.

How to reduce bosque fires and save water

It is estimated that the average annual water loss due to evapotranspiration (ET) in the Middle Rio Grande riparian corridor is 20-35% of that reach's total water depletion (Dahm et al. 2002). Most of the cottonwoods contributing to the depletion are relatively old, and are stressed by low water availability (Leffler et al. 2000, Eichhorst et al. 2002) and leaf beetle outbreaks (Eichhorst 1999). Many cottonwoods dating back to the 1941-1942 floods and earlier (P. Jacobson, unpublished tree coring data) now regularly drop dead branches, as do many shade-tolerant Russian olives in the understory. Thick accumulations of nearly impenetrable dead branches are common on the floor of the bosque. During most of the year the fallen wood and a surrounding layer of dead, dry leaves become highly combustible fuels, especially on dry, windy spring days. When the fuels do catch fire, the dense living and dead woody understory then becomes a conduit that ignites the canopy above (Stuever et al. 1997). It is true that intermittent overbank floods can still deter fires because they clear out much of the fuel on the ground and cover what remains with sediment, creating a moist environment for decomposition (Ellis et al. 1998). However, with the reduction of overbank flooding those effects now seldom take place.

Our proposed solution to the twin problems of the bosque's potential depletion of river water via ET and the increasing frequency of bosque fires, lies in reorganizing the riparian landscape to resemble its historic condition, but doing so within the current constraints on the bosque's active floodplain. Because of the major spatial change that regulation has imposed on the system, attempts to fully "restore" the bosque can never be totally successful. That accepted, we propose that a more realistic way of sustaining the bosque's ecosystem integrity should include the following: (1) carefully controlled overbank flooding or other means of soil moistening, both of which can be accompanied

by bank or soil surface lowering; (2) management leading to improved habitat diversity; (3) wetland construction inside and outside the levees; and (4) a sustained program of research and monitoring. Those goals are consistent with the objectives of the U.S. Army Corps of Engineers Middle Rio Grande Restoration Project, the City of Albuquerque Open Space Division projects; and with those of other planned and ongoing restoration-related programs in the Middle Rio Grande Valley. These include the San Juan, Santa Ana, and Sandia Pueblo restoration projects, and the Save our Bosque Task Force's San Acacia-San Marcial Conceptual Restoration Plan project.

Implementation of the proposed solution will involve selective removal of large numbers of bosque trees so that ET depletions and fire probability are reduced to acceptable levels. Bosque ET appears to be higher in dense stands of saltcedar, and in mature stands of cottonwood containing extensive understories of saltcedar and Russian olive, than it is in less dense saltcedar stands and mature cottonwood stands with few understory trees (Cleverly et al. 2002; Dahm et al. 2002). Thus reduction of tree densities, especially those of invasive species occurring either in monospecific stands or in the subcanopies of mature cottonwood stands, is basic to the proposed solution. Considering that bosque wildfires are fueled both by live trees and dead wood, it will be imperative to remove large portions of both. Given these realities, how does one design and implement an ecologically and socially acceptable plan for such a reorganization of the riparian landscape?

Here is our suggested approach, much of which we have alluded to above. First, we feel it essential to recognize the following four essential components of the proposed reorganization process, and note that some are already part of ongoing or planned restoration activities along the Middle Rio Grande: The four components are (1) removal of most standing and down dead wood of any species, other than small numbers of large cottonwood snags for use mainly by birds; (2) retention but occasional thinning of most native trees; (3) creation of uneven-aged stands of native trees to ensure their long-term sustainable replacement (such stands can be established by combinations of well-timed overbank flooding, pole planting, watering cleared and often lowered areas in late spring with pumped groundwater and/or drainwater, and constructing side channels from the river or drains into partially cleared forest); (4) creation of an irregular and internally thinned mosaic of woodland patches separated by relatively large open spaces.

The reorganization just described will be the rough equivalent of "restoration" in that the proposed woodland patches, even though confined to today's nearly linear active floodplain, will resemble those of the much wider active floodplain of the past (see discussion above). Stands separated by open areas of native grasses and shrubs over distances up to, say, half a mile, will delay the movement of fire and enable firefighting equipment to be brought in rapidly. (Lines of jetty jacks probably will have to be removed first.) The open spaces will therefore act as firebreaks. Application of all four of the restoration components listed above will, in our opinion, result in a savanna-like architecture of mostly native, uneven-aged stands that are much less vulnerable to combustion and more restrictive of water loss than is the gallery forest that constitues the present bosque.

Monitoring the Landscape Alteration

Monitoring the altered landscape before, during, and long after its creation will be key to evaluating its success. Use of the ongoing Bosque Ecosystem Monitoring Program (BEMP) is suggested as a means of tracking hydrologic and ecologic change in the bosque through time. Engaging many hundreds of K-12 students and other volunteers ensures a quality controlled and highly educational activity (Eichhorst et al. 2002). An added benefit of using BEMP is financial: the program relies mainly on volunteers to do most of the monitoring. Expenses will also be greatly reduced by using adult volunteers, under supervision, in clearing and various other tasks during the reorganization.

Concluding Remarks

We conclude by urging that the entire project be *well integrated and ecosystem-based*. We feel it should take advantage of present and past river and riparian research along the Rio Grande, and that it should coordinate with other relevant projects and programs in the basin. We also suggest that it incorporate a seldom discussed but potentially catastrophic situation, namely major flooding of the Rio Grande. This could happen even with the river's present flood control devices in place -- witness the extensive flooding of the upper Mississippi in 1993. Setting aside large tracts of remaining open space, possibly even including farmland, as sumps to receive direct overflows or water diverted through culverts or other openings in levees, could create temporary wetlands such as wet meadows and marshlands that were once common in the valley (Crawford et al. 1993).

In addition, we also strongly suggest that external assessment of both planning and progress -- resembling, for example, the assessment employed by the Kissimee River Restoration Evaluation Program (Dahm et al. 1995) -- will add credibility to the project and flexibility to its operation over time. Finally, we note that many of the recommendations detailed in the Middle Rio Grande Bosque Biological Management Plan (Crawford et al. 1993) are nested in our proposal, and if seriously considered by resource managers will add historical consistency to the proposal's implementation.

Acknowledgements

James Cleverly, Cliff Dahm, Mary Dwyer, Kim Eichhorst, Lisa Ellis, Jennifer Follstad Shah, Steve Harris, Ondrea Linderoth Hummel, Yasmeen Najmi, Manuel Molles, Jennifer Schuetz, Dan Shaw, Mary Stuever, Jim Thibault, and Maury Valett head a list, far too long to include here, of all those who have influenced the ideas set forth in this proposal. We thank them all. We also acknowledge certain individuals whose rationale for bosque landscape alteration as described in this proposal is clearly related to ours; they include Todd Caplan, Gina Dello Russo, Mark Horner, Esteban Muldavin, Jimmy O'Brien, Marcel Reynolds, Matt Schmaeder, Paul Tashjian, John Taylor, and Nancy Umbreit. Finally, we thank Cliff Dahm, Gina Dello Russo, Lisa Robert, and Paul Tashjian for their comments on an earlier draft, and David Gutzler for informing us of key references.

Literature Cited

Cleverly, J.R., C.N. Dahm, J.R. Thibault, D.J. Gilroy, and J.E.A. Coonrod. 2002. Seasonal estimates of actual evapotranspiration from *Tamarix ramosissima* stands using 3-dimensional eddy covariance. Journal of Arid Environments 52: 181-197.

Crawford, C.S., A.C. Culley, R. Leutheuser, M.S. Sifuentes, L.H. White, and J.P. Wilbur. 1993. Middle Rio Grande Ecosystem: Bosque Biological Management Plan. U.S. Fish and Wildlife Service, District 2, Albuquerque, N.M.

Crawford, C.S., M.C. Molles, Jr., and H.M. Valett. 1994. Flooding and conservation in the Rio Grande bosque. 1994. Proceedings of the 39th Annual New Mexico Water Conference, New Mexico Water Resources Research Institute and the American Water Resources Association, WRRI Report No. 290, Albuquerque, NM.

Crawford, C.S., L.M. Ellis, and M.C. Molles, Jr. 1996. The Middle Rio Grande bosque, an endangered ecosystem. New Mexico Journal of Science 36: 279-299.

Dahm, C.N., K.W. Cummins, H.M. Valett, and R.L. Coleman. 1995. An ecosystem view of the restoration of the Kissimmee River. Restoration Ecology 3: 225-238.

Dahm, C.N., J.R. Cleverly, J.E. Allred Coonrod, J.R. Thibault, D.E. McDonnell, and D.J. Gilroy. 2002. Freshwater Biology 47:831-843.

deBuys, W. 1985. Enchantment and Exploitation. The Life and Hard Times of a New Mexico Mountain Range. University of New Mexico Press, Albuquerque, NM.

Eichhorst, K.E. 1999. Dynamics of defoliator activity along an urban to rural grandient in the Middle Rio Grande Riparian Corridor. M.S. Thesis, Department of Biology, The University of New Mexico, Albuquerque, NM.

Eichhorst, K.E., M.C. Stuever, M.M. Dwyer, D.C. Shaw, and C.S. Crawford. 2002. Bosque Ecosystem Monitoring Program (BEMP): First Annual Supplement. Open-File Report 02-2.

Ellis, L.M., C.S. Crawford, and M.C. Molles. 1998. Comparison of litter dynamics in native and exotic riparian vegetation along the Middle Rio Grande of central New Mexico, USA. Journal of Arid Environments 38: 283-296.

Graf, W.L. 1994. Plutonium and the Rio Grande: Environmental Change and Contamination in the Nuclear Age. Oxford University Press, New York, NY.

Horgan, P. 1984. Great River: the Rio Grande in North American History. Wesleyan University Press, Hanover.

Horton, J.L., T.E. Kolb, and S.C. Hart. 2001. Physiological response to groundwater depth varies among species and with river flow regulation. Ecological Applications 11: 1046-1059.

Leffler, S.A., L.E. England, and J. Naito. 2000. Vulnerability of fremont cottonwood (Populus fremontii Watts.) individuals to xylem cavitation. Western North American Naturalist 60:204-210.

Pearce, J.T. 2003. Surficial geologic map of the Middle Rio Grande floodplain, from San Acacia to Elephant Butte Reservoir, New Mexico. New Mexico Bureau of Geology and Mineral Resources Open File Report 476.

Scurlock, D. 1998. From the Rio to the Sierra: An Environmental History of the Middle Rio Grande Basin. USDA Forest Service General Technical Report RMRS-GTR 5, Rocky Mountain Research Station, Fort Collins, CO.

Stuever, M.C., C.S. Crawford, M.C. Molles, Jr., C.S. White, and E.Muldavin. 1997. Initial assessment of the role of fire in the Middle Rio Grande bosque. In: Proceedings: First Conference on Endangered Species and Habitats, ed. by J.M. Greenlee, pp 275-283. International Association of Wildland Fire, Fairfield, W.A.

Wozniak, F.E. 1996. Human impacts on riparian ecosystems of the Middle Rio Grande Valley during historic times. In: Desired Future Conditions for Southwestern Riparian ecosystems: Bringing Interests and Concerns Together, D.W. Shaw and D.M. Finch, tech. coords., pp33-43. USDA General Technical Report RM-GTR-272. US Department of Interior, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.