Flood Pulsing in Restoration: A Feasible Alternative for India?

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Abstract

The full restoration of natural flood pulsed conditions has only been attempted in a few places in the world because the politics behind the original destruction of the wetland generally impedes full restoration. Often the desire to restore wetlands for wildlife and other purposes is not strong enough to alter or eliminate the engineering projects such as embankment, diversion, interbasin water transfer and hydroelectric dams for water, irrigation and electricity that destroyed the original wetland. Unfortunately, we must find ways to provide plant and animal species flood pulsed habitats because many of these are not only adapted to, but dependent on this environment for their continued survival.

The restoration of flood pulsing has been accomplished only in a handful of places such as the Kissimmee River (Florida U.S.A.) and the Lodi Wildlife Area (Wisconsin U.S.A.). At the same time, many partial restorations have been successful removing or working with engineering projects. After the floods of the Mississippi River (U.S.A.), many people moved off the flood plain with the blessing of the Federal Emergency Management Agency. Now, several embankments (levees or bunds) have been removed, and areas are reverting to natural vegetation. Downstream from hydroelectric dams in the Cameroons (Africa) and near Pune (India), impounded borrow areas with bunds have created fisheries/vegetable gardens and wildlife habitat, respectively. Restoration of spring habitats in arid and montane regions can be as simple as removing cattle from the banks of streams as in the case of the “Magic Spring” near Cartago (Costa Rica). The inclusion of flood pulsing in riverine restoration in India is a new idea as it is everywhere, but we must give serious consideration to recreating the original conditions of the habitat for the benefit of the animals and plants that utilize these wetlands.

The Engineering of Rivers Worldwide

Complete restoration of floodplain wetlands must reestablish overflow flooding from river and stream channels across the floodplain (floodpulsing) during the rainy season of the year (Middleton 1999). Because most of the world’s rivers have been reengineered by dams, embankment via levees or bunds, channelization, and/or diversion (Gregory 1977), often the conditions created by engineering projects need to be reversed before successful restoration can occur. However, the dried floodplains created by these engineering projects can make capital investment possible (Pearce 1991), so that, reversing these conditions may be politically impossible. Nonetheless, wetlands are very important to humans. Settlements in India are often directly adjacent to wetlands attesting to their importance for washing, bathing, drinking, livestock and irrigation (Figure 1) (Foote et al. 1996).

Embankments (levees, bunds) are designed to cut-off the transfer of water between the channel and the floodplain (Middleton 1999) and have been constructed worldwide to force the river into the channel and away from floodplains, e.g., along the Mississippi in the midwestern United States, Danube in Central Europe (Cowell 1997) and the Brahmaputra/Ganges/Meghna Rivers in Bangladesh (Brammer 1990a). While such reengineering allows humans to encroach the floodplain, it has serious consequences for the plants and animals that live on the floodplain that depend on the flood pulse for their growth and reproductive
activities (Middleton 1999). Embankments impair the ability of fish to spawn and rear young on flood plains and so can be a serious economic problem in countries such as Bangladesh where 80% of the protein consumed comes from fish (Sklar 1993).

Embankments are dangerous to the humans living behind them since they pose the very real threat of bursting during floods (Middleton 1999). While embankments may protect settlements and farmland from flooding in small flood events, these cause downstream flooding by forcing water away from upstream flood plains (Leopold and Maddock 1954). Over time, embanked farmland develops a lower elevation than the river channel because it does not receive enriching sedimentation from the river as is the case along portions of the Mississippi River (U.S.) and three Chinese rivers (Brammer 1990a). Floods improve soil nutrient levels; agricultural production usually increases the year after a flood, because of the enriching action of flood waters (Brammer 1990b; Rogers et al. 1989).

Breaches in embankments create opportunities for partial wetland restoration on floodplains for the benefit of vegetation, waterfowl and wildlife (Trepagnier et al. 1995). After the floods of 1993-94 along the Mississippi River in which the majority of embankments burst along the river near St. Louis, MO, some of the embankments were not replaced because it was realized that the river had been constrained too far. Entire villages of peoples moved off of the floodplain after this major flood with the encouragement of the Federal Emergency Management Agency (U.S.) (Middleton 1999). In areas designated for flood retention along the American Bottom near St. Louis, embankments were removed or moved back from the Mississippi River. Natural vegetation reestablished in those places spontaneously from seed bank and seed dispersal processes but it did not resemble its original composition (Giedeman 1999).

Stream Diversion and InterBasin Water Transfers

The diversion of water away from a river for irrigation or drinking water obviously has a big effect on the volume of water involved in the flood pulse on the floodplains of rivers and thus has huge consequences for the biota along the river. Irrigation projects are common in arid lands and India has irrigation canals that have been operational for hundreds of years (Ali 1982). However, the consequences of these activities have been little considered from the perspective of wetland conservation and restoration.

Any engineering project that transfers water from previously unconnected water bodies creates a new corridor for the flow of water and biota. Such interbasin
water transfers curtails the transfer of genetic material along the original corridor, and creates a new avenue of genetic transfer where none existed before. Other threats along these altered corridors include the invasion of new species of animals and plants, change of water quality and the spread of disease vectors (Davies et al. 1990).

Dams

Many significant rivers have been dammed in India (World Wide Fund for Nature India 1993) and some of these dams are thought to have been built as early as 3150 BC (National Committee for Geography 1968). While dams to create rice paddies and fish ponds create wetlands, these also destroy wetlands by diverting water from downstream areas (Foote et al. 1996). Large dams in particular threaten humans. Dams sometimes burst and cause human death and destruction, not to mention the thousands of people that are displaced by the construction of dams in the first place (Costa 1988).

Everywhere in the world, dams change biological processes both up and downstream regarding water flow, sedentation, nutrient cycling and energy exchange (Sparks et al. 1990). Upstream from dams, sites become permanently impounded with little water fluctuation. Downstream, water is often reduced to a trickle. Worse yet for the biota, the operations of a hydroelectric dam, water is released suddenly and during inappropriate seasons of the year. This has severe consequences for those biota that are unable to adapt to these sudden extremes in water and sediment conditions (Middleton 1999). Dam building began along the Chambal River in the 1960s, and subsequently, crocodile number dropped because these could not adapt to the changes in the waterway (Sharma and Singh 1986).

Though an attractive idea, dam removal has not been uniformly successful in restoring wetlands. One big problem is that sediments build-up behind dams, and opening them allows a sediment plume to move downstream (Simons 1991). Sediments behind the dams can be difficult to revegetate (Shuman 1995). In certain cases, the sediments behind dams have toxins (e.g., PCB) and thus are an environmental hazard (Shuman 1995; Tofflemire 1986). Controlled releases of water from dams show some promise for simulating flood pulses and this has been tried with some success in the Grand Canyon of the U.S. since 1996 (Stevens 1997).

Restoration in a Water Regulated World

Effective restoration needs to be accomplished at the landscape level. Paradoxically, the procedures used to destroy wetlands were typically accomplished at that level. To undo these problems, we need to rethink our approaches on the same large scale (McCorvie and Lant 1993). There are only a few examples of rivers or streams being restored on a landscape level in an attempt to put them back into their original condition and those include the Kissimmee River project (Florida, U.S.A.) and the Lodi Wildlife Area Project (Wisconsin, U.S.A.) (Middleton 1999).

Why should we attempt to create the original conditions in wetland restoration with flood pulsed conditions? Restoration attempts that have not attempted to recreate the original conditions have not been very successful. While wetland restoration has been practiced for at least 30 years in the United States, many of these have been deemed failures because of hydrological problems. While little study exists of their success, in one study based mostly in Florida (USA), less than 63% of the wetland restorations were successful (Erwin 1991).

The key to restoration is to provide species with the environment to which they are adapted. The life history of some species are so closely tied to a flood pulsed environment, that these cannot survive without it. Most plant species germinate and their seedlings only thrive in drawdown conditions (Middleton 1999). Not surprisingly, species of monsoonal wetlands are closely adapted to annual drawdown stemming from the yearly drought (Finlayson 1991; Middleton 1999; Middleton et al. 1991). In the Amazon, a millipede species (Cutervodenus adisi Golovatch) spends the flood season on tree trunks, and reproduces only on the drawdown forest flood (Adis et al. 1996). In cases where life history is very closely adapted to the flood pulsed environment, if that environment is altered by human engineering projects, the species will not survive (Middleton 1999).

Admittedly, natural flood pulsing on the flood plain is sometimes unacceptable for purely political reasons. If the goal in a region is to use all or even part of the flood plain for housing, agriculture or other human purposes, it is essential to control unpredictable flooding on the flood plain. However, the reality is that people cannot be completely protected with either embankments or dams for the purpose of holding back the water during floods. The devastating and recurring floods along floodplains of the Mississippi River (Mississippi River Corridor Study Commission 1995), the Danube in Europe (Cowell 1997) and Brahmaputra/Ganges/Meghna Rivers in Bangladesh
(Brammer 1990) have taught us that we can not control rivers all the time.

There are some very successful projects that partially restore flood pulsing along rivers. The Project Pisciculture Lagdo has maximized water for fisheries and vegetable farming along a dried floodplain downstream from the Lagdo Reservoir along the Benue River in Cameroon (Slootweg and van Schooten 1995). In addition to creating wetlands downstream from the hydroelectric plant, the project also helped to compensate fishermen for the loss of their resource after the dam was put in place.

The Ecological Society of India has created borrow areas with small bunds to impound water below the Panshet Dam near Pune, India. The project has created wildlife habitat for a large variety of birds, fish and amphibians (Middleton 1999). In upland areas of the same watershed, the hillsides were stripped of vegetation. Natural revegetation occurred and created habitat for a wide variety of wildlife after cattle were excluded (Gole 1990).

Other wetland restoration projects have only been successful after cattle have been excluded, particularly in arid and/or montane situations. In Costa Rica, one mountain stream dried up because of cattle grazing near Cartago, Costa Rica in the Vulcán Irazú watershed. After the cattle were removed, water flow returned to this stream. The “Magic Spring” that had been sacred to the indigenous tribal people there, reappeared as a permanent water body (Don Angel Rodriguez and Margarita Boloños, personal communication).

It would seem that either full or partial wetland restoration projects have been accomplished throughout the world. The benefits of wetland restoration are clear for the preservation of the world’s threatened biota, but at the same time can be equally beneficial for humans. All flood plains cannot be made completely safe from dangerous floods, and certainly some of these can be put to better use as wetland habitats. In addition, engineering projects can be made to accommodate the needs of people and wildlife to a greater extent than they have in the past. These approaches all present opportunities for wetland restoration in India and other parts of the world.

**Literature Cited**


