What is Restoring Bottomland Hardwood Forests? A Study From the Lower Mississippi Alluvial Valley

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Introduction

The interest in changing the use of the Lower Mississippi Alluvial Valley (LMAV) floodplain has been gathering momentum. Recent changes in federal farm programs, heightened awareness of the value of forested wetlands and increasingly productive farming practices have allowed for consideration of land use changes. Marginal agricultural land in the LMAV, cleared at the time of soaring soybean prices, is no longer looked upon as being favorable only for agriculture. These lands, usually deemed marginal because of seasonal high water, are being offered for reforestation. These once forested tracts of land are being converted from row agriculture back to some form of a bottomland hardwood ecosystem.

Restoration is one of those terms loosely defined and often loosely applied. In the LMAV, bottomland hardwood forest restoration has attracted heightened interest. It has been estimated that 80 percent of the bottomland hardwood forests in this area have been converted to other uses over the past 40 years, Today, there is renewed activity in restoring these systems. Much of the impetus for this activity revolves around federal cost share programs, in particular the Wetland Reserve Program (WRP), which provides payments to landowners interested in reestablishing native bottomland systems. The problem is obtaining a clear definition of restoration and quantifying the different spatial and ecological entities involved in restoration success. Virtually all success criteria designated for restoration efforts involve a study only of physiognomy of restored vegetation. Currently absent from the restoration plans/goals are explicit statements regarding the restoration of hydrologic, edaphic or faunal components. Restoration involving forested systems is a long-term endeavor and cannot be handled properly with quick fixes. It is agreed that reforestation success does not equal restoration. There still exists controversy over the reforestation success criteria used for WRP in the LMAV. We must decide criteria based on sound science, using integrated fact-based management, and be aware of the consequences. Additionally, these systems and the restoration attempts must be viewed on a landscape scale, with off-site impacts kept in mind. The degree of good management people have attained and are willing to obtain should also be weighed in conjunction with clearly defined goals and criteria for success.

Much of the. reforestation in this area on abandoned agricultural lands is being done in conjunction with the WRP. WRP is administered by the Natural Resources Conservation Service (NRCS). WRP is a federal technical assistance program aimed at private landowners. Eligible landowners receive compensation through an easement payment based on the agricultural value of the easement area, and through cost-share of restoration costs. The program objectives for WRP are to: 1) purchase easements from willing landowners; 2) assist eligible landowners to restore the hydrologic conditions of inundation or saturation of the soil, native vegetation and natural topography of eligible lands; 3) protect and restore the remaining values of agricultural wetlands; 4) help achieve the national goal of no net loss of wetlands; and 5) improve the general environment of the country (NRCS 1995).

WRP requires NRCS to provide leadership for program direction, in concurrence with the Farm Services Agency and in consultation with the U.S. Fish and Wildlife Service and other cooperating agencies. Using criteria established by the state technical committee, NRCS district conservationists develop WRP plans of operation for each contract in their respective districts. These plans contain a site evaluation, and include identification of soil type, hydroperiod and species compatibility.

Reforestation, was the main restoration interest emphasized under the 1992 WRP plans in the LMAV. The general goal was to shift and accelerate the successional pattern by reinstating one or more natural elements, with all efforts focused on introducing hardwood species. The introduction of hard mast species was the main thrust, oaks in particular. The reasons for oak introduction on these abandoned agricultural fields were: 1) to introduce a species that has been deemed an important wildlife food source; and 2) to introduce a species that had a reduced chance of natural introduction. Because of the extensive loss of bottomland hardwood forests and, thus, limited seed sources, and the isolated location of many of these WRP tracts which makes for long seed dispersal distances, the chance of natural regeneration of oak on these sites was circumstantially minimal.

Methods of reforestation on these abandoned fields usually followed one of two widely used methods. Seedlings of 1-O bareroot nursery stock were machine or hand planted on a field that had been prepared for planting by double disking. The planting rate was 302 trees per acre (12- by 12-foot spacing or 746 per hectare [3.7 x 3.7 m]). The other method involved direct seeding acorns.

Fields were prepared the same as for seedling planting, and acorns were machine planted using a modified soybean planter at a rate, of 1,210 acorns per acre (12- by 3-foot spacing or 2,989 per hectare [3.7 x 0.9 m]). Both methods have been studied, and success rates are reported to be between 57 and 98 percent survival for seedlings (Allen 1990, Krinard and Kennedy 1987, Wittwer 1991, Savage et al. 1989, Schweitzer et al. 1997). Johnson and Krinard (1985) suggested that 35-percent survival might be expected for operational direct seeding, although some of their research trials have shown survival as high as 80 percent, while others have reported survival as low as 11 percent (Schweitzer et al. 1997).

In 1996, a survey of 47 WRP tracts enrolled in 1992 in the LMAV was performed. The purpose of this survey was to assess reforestation success on these tracts. Soil and hydroperiod have no set or measurable criteria for success under WRP and were not considered in the assessment. Hundredth-acre plots (0.004 ha) situated along set transects were used to estimate tree establishment numbers on each tract. The success criteria specified under WRP guidelines was 125 hard mast stems per acre (309 ha-i) after three years. Modifications due to the large scale of this assessment and our attempts to conduct the sampling under a statistically valid scheme caused us to modify the criteria to 100 trees per acre for success (247 ha-‘). Out of the 9,387.7 acres (3,802 ha) reforested under 1992 WRP, 8,800.4 acres (3,564 ha) were direct seeded with species of *Quercus*, and 587.2 acres (237.8 ha) were planted with 1-O bareroot seedlings. Overall, only 9.3 percent of the reforested land had an average of 100 trees per acre after 3 1 growing months. Twenty-three percent of the land that was planted with seedlings averaged 100 trees per acre after 3 1 months, and 8.4 percent of the land that was direct seeded averaged 100 trees per acre. The plans for these sites have been revisited, and the tracts are proposed to undergo more extensive rehabilitation. The lack of reforestation success brought to light questions concerning establishment procedures and requirements.

Monitoring

Monitoring is critical to ensuring that the objectives of a given project are being achieved and to finding out what went wrong when it fails (Shear et al. 1996). While there are many factors that can be used to monitor progress of “restored” wetlands, observing vegetation has often been the easiest and probably the most common method. The most appropriate monitoring tools may be simple guides such as species number, and must be maintained over an agreed period of time (Shear et al. 1996). Functions such as floral and fauna1 population dynamics, biogeochemical cycling and hydrological cycling are difficult to monitor. Although functional success cannot be guaranteed, there are many ways to reduce the risks of failure by monitoring structural attributes. Assessment methods used to determine levels of functions may be absolute measurements or measurements relative to some reference stands (Brinson and Rheinhardt 1996). Easily measured parameters such as plant lists, animals witnessed or percentage vegetation cover as overall criteria may or may not accurately reflect wetland functions (Mitsch and Wilson 1996). However, monitoring some factors can assist practitioners in the next step of their restoration.

The establishment of long-term monitoring plots, used to check survival in an organized manner, are simply not a common part of reforestation plans. Granted, this monitoring is costly in terms of time and travel. However, if after 10 years it is discovered that the desired habitat has not been established, it is also costly, perhaps more so, to replan, reprepare the site and replant. If establishment performance is closely monitored, landowners and managers can continually review their target population numbers and change, improve or supplement practices accordingly.

This gathering of "sound data" does not include causal visual surveys of planted seedlings. These surveys are most often too subjective and impossible to evaluate and document adequately (Neumann and Landis 1995). Documentation of establishment results is also needed to complete program performance reports. If the goal is clearly stated as some given number of trees per acre, we cannot be satisfied with a final product of only land retirement.

Most of our experience in establishing bottomland hardwoods on old field sites has been done on a small scale. Expanding the existing knowledge of tree establishment to a large scale must be done with care and consideration. Reforestation must be viewed as a long-term undertaking and a continuous process. Those cases where successful, large-scale reforestation has occurred were implemented by forestry professionals. We must not remove the forester from this practice. We would not expect a forester to implement row crop planting, so in return, it is difficult to imagine the expectations of allowing farmers to implement a tree establishment program. Under WRP in 1992, the plan of operation was implemented by the landowner, who then turned to private vendors to obtain seed or seedlings and do the actual establishment operations. These landowners and vendors did not go through any training relative to hardwood tree establishment procedures, and quality-control provisions were lacking. We need to explore ways to transfer the reforestation knowledge we have, and create effective oversight and enforcement of establishment procedures. A critical step in the reestablishment of a forested ecosystem is the initial establishment of trees (Ashby 1997). Noncompliance in the initiation phase can have detrimental consequences.

Flora

Clearer objectives need to be set for the targeted, desired flora, so that management and monitoring can be planned. First, the desired output of the restoration process must be defined. In the case of the 1992 WRP tracts, the efforts of input centered around tree establishment, so that the monitoring for success then centered around tree survival and numbers per acre. However, restoration does not equal reforestation. Notably absent from most project goals are any explicit statements regarding the restoration of the hydrologic, edaphic or faunal components of a bottomland hardwood system.

Concerns exist over the actual goals and objectives established under WRP guidelines. One hundred and twenty-five hard mast stems per acre after three years was the set criteria for successful reforestation under WRP. Out of the seven tracts that had at least 100 trees per acre, only one had more than 125 trees per acre. These trees were not tall enough to record diameters at 4.5 feet d.b.h. (1.37 m). Goelz and Meadows (1997) suggested using stocking guide equations to guide initial spacing of hardwood plantations. In one of their scenarios, plantations that will never be thinned, but that will achieve 133-percent stocking before natural mortality occurs, were used to calculate initial planting densities. At 75-percent survival, to meet these given criteria, a plantation would initially have to have between 436 and 1,135 trees per acre, depending on tree growth rates and subsequent tree diameters between 5 and 9 inches (12.7-22.9 cm). After 10 years of growth, the diameters of bottomland hardwood plantation oaks have been reported to range between 1.7 and 3.1 inches d.b.h.(4.3-7.9 cm) (Kennedy et al. 1987). After 15 years of growth on heavy clay soils and with mowing to control herbaceous competition, Krinard and Kennedy (1987) reported Nuttall oak (*Quercus nuttallii*) diameters at 4.0 inches (10.2 cm). If one considers future management of these WRP tracts, the initial step would be to decide if the stand can be managed (the alternative being to regenerate again). Manuel et al. (1993) used d.b.h. classes from Putnam et al. (1960) to indicate the maximum contribution a tree can make toward a fully stocked stand. The 100 trees per acre needed to meet the success criteria would have to average 10 inches (25.4 cm) d.b.h. As the number of trees per acre decreases, the average d.b.h. needed by the remaining trees to achieve full stocking increases. It does not seem probable, given the low number of trees needed to meet the WRP success criteria, the lack of volunteer tree invasion and the given growth rates, that full stocking will be achieved on these sites.

Over time, we can only expect trees to be lost from the stand due to stresses. Unfortunately, natural invasion cannot be depended upon on these sites (Allen 1990). A pragmatic approach would be to plant at a higher rate than what is needed. The rationale behind this is that one increases the odds of establishing a fully stocked stand. Other options would also center around more intensive establishment procedures, such as also introducing light-seeded species or using a nurse crop such as cottonwood ***(Populus deltoides)*** as a pioneer species to settle the site initially, followed by the interplanting of oaks. Also, it is much easier and more economic to remove trees in an overstocked stand than it is to add lo-year-old trees in an understocked stand. By starting with a stand that has plenty of potential for future management, natural resource managers are much more apt to be able to manipulate the stand to achieve landowner objectives.

Hydrology

In 1992, the only cost input on the WRP tracts in the LMAV was for tree establishment (besides easement purchase). In forested wetlands, hydroperiod is the most important factor influencing productivity (Conner 1994). However, submergence of newly established trees can be deleterious to individual tree species, depending on the season flooded, the depth of flooding and the duration of the flood event (McKnight and Johnson 1975). It has been suggested that maintaining shallow water levels during the establishment phase is advantageous to seedling survival. One private landowner in the LMAV actually used pumps to remove high water from his WRP tracts. He did this for two growing seasons and reported close to 95-percent survival (C. Phillips personal communication: 1998). Therefore, the lack of initial restoration of some artificial hydroperiod on these WRP sites should have enhanced survival, as high water can be a nemesis for seedling survival. This was not the case. Many factors may have contributed to low survival, including acorn collection and handling, planting techniques, competition, depredation by small mammals, weather, species selection and a combination of all these. Without careful monitoring it is difficult to ascertain the causes of these low tree establishment percentages.

In practice, it is seldom possible to restore the original (precolonial) hydroperiod on a given site. The massive alterations on a regional scale (e.g., the Mississippi River main levees) and more localized scales (e.g., drainage canals) make true hydrological restoration impossible. In a region such as the LMAV, where a structure holding 1 foot of water at its head will back water up to 1 mile behind it, off-site impacts imparted by creating artificial water levels must be considered. And if hydroperiods are carefully designed to mimic seasonal fluctuations, someone must be responsible for the on-site maintenance of these practices. Proposed penalties or incentives that seek insurance of maintenance and no off-site impacts must be considered and enforced. Finally, hydrology is the fundamental forcing function of forested wetlands (Mitsch and Gosselink 1986). When considering the water budget for these systems, one major driving component, especially in older systems, is evapotranspiration. Evapotranspiration is seasonal, with peaks in summer and low rates in winter. As evapotranspiration is dependent on water flowing through vascular plants, the number and type of plants present will influence evapotranspiration rates. Again, one must not lose sight of the importance of tree species establishment. Without the establishment of transpiring trees, a water budget that mimics the natural hydroperiod is not possible.

Soil and Fauna

Soils on these sites have been altered by years of farming but generally still support adequate tree growth. Monitoring of soil restoration is not common, although attempts are being made to observe the recovery time of an abandoned field and to relate changes in time to an undisturbed forested site (J. Stanturf person communication: 1997). It is rare that any soil amelioration beyond breaking up compacted layers is attempted.

Heavy-seeded tree species typically have more value than light-seeded species for many birds and mammals favored by wildlife managers (Martin et al. 1951). However, comparing the wildlife value of a reforested field with a mature bottomland hardwood forest is not credible. The comparison first needs to be made with a non-forested old field, or to the previous status of each individual site. It does appear that the replacement of a targeted wildlife value, although this value has no defined or measurable terms, is being hindered greatly by insufficient establishment and subsequent lack of ingrowth of heavy mast species.

Recommendations

There is no set recipe for successful restoration or reforestation. Those involved with bottomland hardwood ecosystems are only beginning to understand their complexities. Therefore, we must evaluate each site and develop appropriate plans. A single management protocol for even one species is probably impossible. Measurable goals need to be set so that we can increase our knowledge and report program performances. Finally, active, intensive establishment and management are required on these sites.

Some additional recommendations, based on work within the 1992 WRP contracts and on-site evaluations, include paying more attention to enforcing requirements, greater specificity in plans of operation, more detailed record keeping and tracking of data, more consistent allowable practices, and more adequate inspections and enforcement. Race and Fonseca (1996) suggested that conflicting goals among agencies, lack of customized plans, lack of performance bonds, inexperience, and absence of a structure to assure long-term accountability for the maintenance of a site all conspired to produce meager results in mitigation wetlands. Some explanations for poor success in the 1992 WRP tracts include lack of skill by contractors, inadequate design (including site preparation), species-site compatibility and selection, seed and seedling quality control, exposure to severe weather, high water, invasion of exotic species, rodent depredation, and weed competition. With proper planning, implementation and monitoring, we can come closer to meeting our goal of restoring these bottomland hardwood forests.

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