Acorn Planting

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BOTTOMLAND FOREST REESTABLISHMENT EFFORTS OF THE U.S. FISH AND WILDLIFE SERVICE: SOUTHEAST REGION

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ABSTRACT: Beginning in late 1987, the U.S. Fish and Wildlife Service (Service) began an aggressive effort to reestablish bottomland tree species, primarily within the Lower Mississippi River Alluvial Valley (LMRAV). Prior to 1987, the Service had planted several thousand acres on national wildlife refuge lands in the Southeast Region. The oldest planting is now about 24 years old. Since 1987, the Service has planted about 27,000 acres on lands transferred to the Service from the Farmers Home Administration and on private lands. The Service has used both the planting of acorns (primarily heavy-seeded oaks) and seedlings of selected species under a variety of conditions with variable degrees of success. In most cases, failures have been attributed to uncontrollable natural fluctuations in weather events (e.g., drought, flooding). However, other specific factors that possibly could have been controlled were noted (e.g., poor seed source, improper handling of seedlings/acorns, failure to properly match species with site conditions, etc.). A variety of cultural treatments and modified equipment has been used in these reestablishment efforts, including an experimental use of a small airplane to disperse acorns over the planting site. Monitoring approaches, data collected, issues needing additional attention and recommendations based on input from the Service's operational field staff are discussed.

INTRODUCTION: Extensive clearing and draining of bottomland forest ecosystems has occurred since the 1700's. For example, in the LMRAV, approximately 5.9 million acres (circa 1980's) of the original 24 million acres (circa 1780's) remain (Hefner and Dahl 1993).

Beginning in late 1987, the Service, Southeast Region, began an aggressive effort to reestablish bottomland forest ecosystems, with emphasis focused on restorable sites within the LMRAV. Efforts have been directed primarily to the planting of selected tree species [e.g., heavy-seeded oaks (*Quercus spp.*), cypress (*Taxodium distichum*)] on abandoned and/or marginal croplands, and the removing or modification of on-site drainage systems to restore or partially restore hydrologic functions. Efforts have been facilitated through our private lands initiative (Partners for Wildlife Program and implementation of the North American Waterfowl Management Plan), as well as through numerous opportunities available as a result of the 1985 and 1990 Farm Acts (e.g., Farmers Home Administration inventory lands, Conservation Reserve Program, Wetland Reserve Program) (Haynes 1992; U.S. Congress 1990, 1987, 1985; U.S. Department of Agriculture 1993, 1991; U.S. Fish and Wildlife Service 1986). Since late 1987, the Service has planted or contracted the planting of bottomland tree species on over 30,000 acres of various land types within the Southeast Region (Table 1). An additional 20,000 acres are targeted for planting (mostly within the LMRAV) over the next 5 years.

TABLE 1. BOTTOMLAND FOREST TREE PLANTINGS SINCE 1987: U.S. FISH AND WILDLIFE SERVICE, SOUTHEAST REGION.

TYPE		ACRES*
Private		13,957
FmHA Transfer Lands		13,160
Other Refuge Lands		3,000
	TOTAL	30,117

*Includes acres scheduled for planting in Fiscal Year 1993.

The purpose of this paper is to provide a summary of applied, operational information about the Service's bottomland forest planting efforts over the past 6 years. Most of the information presented herein was provided by Service biologists based on their field observations. These observations have not been statistically analyzed; thus, definitive conclusions should not be made, except in those cases where existing scientific information is adequate to support such conclusions. Information is provided under the following categories: site preparation, species planted as related to hydrology and soil types, planting methods and equipment, sources of plant material, planting times, and monitoring and research needs.

No effort has been made in this paper to provide a comprehensive literature review on this subject. However, in recent years the Service has published an annotated bibliography of bottomland forest reestablishment on disturbed sites (Haynes, Allen, and Pendleton 1988), a layman's guide to bottomland reforestation in the Lower Mississippi Valley (Allen and Kennedy 1989), and several other informative papers (Allen 1990, Haynes and Moore 1987).

RESULTS

Site Preparation: Site preparation is carried out to establish suitable conditions for tree seed or seedlings; or, in some cases to improve site conditions for the use of planting equipment and monitoring.

In carrying out tree planting operations, Service personnel typically minimize site preparation in order to reduce costs. Since the Service's planting objective is to ensure a timely reestablishment of heavy-seeded species in the forest ecosystem, and not commercial timber production, some mortality and reduction in growth due to competition from unwanted vegetation are acceptable.

Most field personnel have noted that site preparation may not be necessary whenever seedlings or acorns are to be planted on sites that have recently been in an active farming operation. However, over several years idle land may become so densely vegetated (including unwanted woody plants) that planting the site either by hand or with mechanized equipment is difficult, and mortality of young trees may become a significant problem. This may be especially true for exceptionally heavy growth of Johnson grass and vines, which have been shown to reduce germination and survival of young trees on some sites. Also, dense vegetative growth on a site prior to tree planting is conducive to high rodent, rabbit, and deer populations, thereby causing additional problems. Rodents will dig up and eat acorns, while rabbits and deer may eat young seedlings. In general, the longer an area lies idle before planting trees the greater the possibility of these problems.

The Service has used various types of site preparation methods. These include disking, mowing, burning, bush hogging, scalping, or various combinations. Disking of a site is almost always done within several months of planting. Mowing is limited by the size of woody vegetation on the site and may also be the least effective method. This is because mowed vegetation responds with rapid regrowth, possibly resulting in even more competition with the planted trees than would have occurred if the site had not been mowed. Burning is sometimes used when grasses and herbaceous plants occur on the site, but considerable planning and safety precautions are necessary when using this method. Probably the most widely used methods on sites that have been idle for several years is to bush hog or scalp (e.g., lower fire plow just enough to strip off vegetation) the area; then, disk one or two times just prior to planting the trees to remove any new vegetative growth and to loosen the soil.

Whenever acorns are direct seeded into heavy-clay soil types, double disking (two passes with the disk plow or harrow at a depth of at least 6 inches and preferably 8 to 15 inches) is recommended. Field observations have revealed that when acorns are planted in heavy-clay soil without disking, the soil often cracks at the seed furrow because of the use of the mechanized disk opener and packing wheels. Extreme temperature changes causes shrinking and swelling of the clay soil, resulting in cracking of the soil and exposure of the acorn (often to extreme heat and drying), thereby causing mortality. Since disking can also create a harsh environment because the newly exposed seedbed dries quickly, it is important that planted areas receive rainfall soon after planting. Whenever possible, Service personnel plan their planting to occur just prior to the passing of a weather system expected to produce rainfall.

The Service does not typically use fertilizers or herbicides in its tree planting operations. Although these amendments may be appropriate for commercial operations, any benefits to seed germination, growth, and survival of trees would seldom justify the additional costs given the Service's planting objectives.

Species Planted/Hydrology and Soils: It is critical that the species selected for planting are matched to the hydrologic and soil conditions that exist and are expected to exist on the site. The plant-species composition of bottomland forest ecosystems is complex and variable, with certain species situated along environmental gradients that are strongly influenced by the degree (e.g., extent and duration) of flooding or inundation during the growing season. Over 100 species of woody plants may occur in periodically flooded bottomland ecosystems. These species exhibit varying degrees of adaption for survival in poorly-drained and poorly-aerated soils (e.g., from the wettest and most poorly-drained to drier and less poorly-drained). Considerable information is available regarding the adaptions of various bottomland tree species to hydrologic, edaphic, and other site factors (e.g., Burns and Honkala 1990; Wharton, et al. 1982; Clark and Benfirado 1981). A general rule of planting is that on an environmental gradient from the wettest to the driest site conditions a species that is adapted to poorly-drained and poorly-aerated soil conditions [e.g., cypress and overcup oak (*Quercus lyrata*)] can be planted successfully on drier sites, but species not adapted to such wet-soil conditions cannot survive when planted on lower sites.

Any competent natural resource manager is aware of these species-site relationships. However, failure to follow these requirements in actual site-specific planting situations is one of the most common causes of planting failures. For example, those responsible for planting may not have accurate site information regarding hydrologic cycles and soil conditions; without proper supervision and a clear understanding of the planting scheme, contractors may plant species inappropriately; very atypical situations may be encountered at the scheduled planting time (e.g., extreme drought or flooding), and trees are prematurely planted rather than waiting until planting conditions are suitable; or, appropriate tree seed or seedlings may not be available when needed, and the site is planted with marginal species, realizing that there is a risk of failure.

The Service has emphasized the planting of those species that are generally believed to need assistance in their establishment (especially on large, abandoned cropfields where the distance to the nearest seed source is more than several hundred feet), and those species that provide important benefits to wildlife. Selected species have been planted (tree seed or seedlings) according to their adaptation to saturated soil conditions and flooding. Most often these have included: (1) cypress seedlings in the most frequently inundated areas; (2) moderately tolerant species such as Nuttall oak (*Quercus nuttallii*), willow oak (*Quercus phellos*), overcup oak, pin oak (*Quercus palustris*), green ash (*Fraxinus pennsylvanica*), and water hickory (*Carya aquatica*) on sites that may be saturated or flooded for up to several months during the growing season; and, (3) weakly or less tolerant species such as Shumard oak (*Quercus shumardii*), swamp chestnut oak (*Quercus michauxii*), cherrybark oak (*Quercus falcata*), water oak (*Quercus nigra*) (also somewhat moderately tolerant), and pecan (*Carya illinoensis*) on sites expected to be saturated or flooded for a few days to a few weeks during the growing season.

The Service has assumed that diversity of tree species on the areas planted will be achieved given sufficient time as a result of the lighter-seeded species invading by natural means from adjacent seed sources (e.g., wind-blown seeds). Some field personnel have recommended planting of invader species whenever the seed source is greater than 1/8 mile (660 feet). Additional research information on this subject is needed.

Planting Methods and Equipment: A variety of planting methods and equipment has been used, ranging from hand planting of seeds and seedlings to the use of modified farm equipment, and even broadcast spreading of acorns using a small airplane. Space limitations do not allow for an in-depth discussion of planting methods and equipment used, but considerable information is available in the literature (e.g., Allen and Kennedy 1989; Haynes, Allen, and Pendleton 1988). Only a few related topics have been selected for discussion herein.

In recent years, the Service has used direct seeding of acorns (primarily red oak species) extensively whenever seeds were available. This choice was made primarily because of the lower cost of direct seeding (about half or a third as much as planting seedlings). Considerable discussion within the Service and with other agencies has occurred regarding the merits and effectiveness of direct seeding and planting seedlings. Both methods have their advantages and disadvantages as summarized in Table 2. Although planting seedlings may result in faster initial establishment and growth, direct seeding in the LMRAV is expected to meet the Service objective of establishing selected heavy-seeded species in the forest ecosystem to achieve biodiversity and wildlife value, with a minimum investment of time and money (Allen 1990).

TABLE 2. SOME PROS AND CONS OF DIRECT SEEDING AND PLANTING SEEDLINGS.

DIRECT SEEDING

Pros

- Typically about half to one-third as expensive as planting seedlings.
- Roots develop naturally without problems caused by disturbing roots and removing seedlings from nursery.
- Acorns may remain in a dormant state for a period of time under adverse site conditions (drought or too wet), thereby increasing survival potential.
- Can plant twice as fast, normally using a two-row planter vs. one row with a seedling planter.
- Proven method of reforestation when site is properly prepared using viable seed that has been properly stored.
- Window for planting is longer than for seedlings (acorns can usually be planted successfully from October through April or May).

Cons

- Proven reliable only for oaks and some other large seeded species.
- Slower initial establishment and development, although long-term growth and survival may not be significantly different from seedlings.
- Local acorn supply for one or more species may be scarce or difficult to obtain from commercial sources.
- Rodents can sometimes be a problem by digging up and eating the acorns; however, planting in large open fields typically results in little damage.
- Cold storage of acorns is generally limited to red oaks and sweet pecan. White oaks do not store well for periods greater than 3 months.
- Acorn-adapted planters (i.e., J.D. Max-Emerge 7100, converted) have more working parts, thus more potential for breakdowns than seedling planters.
- More difficult to monitor success, since it takes several years for germinated seedlings to become large enough to find easily.

PLANTING SEEDLINGS

Pros

- Planting tree seedlings is a reliable and well established method of reforestation.
- Usually a good selection of reliable commercial suppliers of seedlings; seedlings available for many species.
- Initial seedling development is faster than for planting acorns, although long-term growth and survival may not be significantly different.
- Taller seedlings may be able to survive flooding events during the growing season if water does not top the seedling for extended periods.
- For monitoring compliance and determination of planting success, planted seedlings are easier to locate than newly germinated seedlings from acorns or other seed.

Cons

- About 2 or 3 times as expensive as direct seeding of acorns.
- Seedlings subjected to adverse site conditions (drought or severe flooding) will perish quickly.
- Seedlings must be planted during the dormant period (January through March) when many bottomland forest sites may be flooded. Planting in extreme wet conditions must be done by hand.
- Seedlings that have been fertilized in the nursery are a preferred food for rodents and deer.

The Service usually sets a survival goal of about 125 planted trees per acre within 5 years after planting. Various planting densities for direct seeding or seedlings can be achieved by using different sowing and spacing patterns (Table 3). When direct seeding is used, a reasonable estimate is that only one out of four acorns sown will produce a tree still surviving after 10 years (25 percent survival rate). Using this survival rate, planting acorns on a spacing of 9′ x 10′ would yield an estimated 121 trees per acre. With seedlings, higher survival rates are expected (Allen 1990); thus, planting on larger spacings (e.g., 12′ x 12′ or 12′ x 15′) is recommended (Table 3).

winter dormant season (e.g., beginning about January 1) through mid-March. The Service has obtained varying degrees of planting success and failure throughout all months of the year; however, the lowest survival rates have occurred during the months of June, July, and August. Typically, the Service no longer plants during these months.

Monitoring: Because of limited funding and personnel, the Service has not often been able to conduct extensive scientific monitoring of its tree planting efforts to the extent desired or needed to obtain optimum information. In many cases, only visual spot checks (one or several times a year) to assess germination and survival have been possible; however, more intensive monitoring efforts have been carried out on some sites.

Field personnel recognize the importance of monitoring reforestation efforts in order to evaluate the success or failure of various planting methods under different environmental conditions, and to obtain information that may prove helpful in future planting efforts. In this regard, a summary of some recommendations from field personnel, based on their applied experiences, is provided below.

1. Establish a goal and measurable criteria for determining success or failure of the planting effort. For example, from the Service perspective a planted site may be considered successful if the average stem count of planted species is at least 125 stems/acre after several growing seasons. However, from a commercial timber harvest perspective, 125 stems/acre would probably be considered a failure. Another criteria could be that if the planted species and natural invaders of the same species are less than one-third of the total species onsite, a supplemental planting should be considered.

2. Seedlings should be sampled by flagging each individual seedling along each row for a given distance (e.g., 50 feet) to achieve the desired sample size. For both seedlings and acorns planted in rows, use a 1-foot sampling zone on either side of the row for the specific sampling distance (e.g., 50 feet). A 2-percent sample of the total area planted is recommended.

3. Mark planting rows with clearly visible engineering flags placed about every 10 feet. Flags colored other than red or orange are recommended, since rodents and other wildlife (e.g., nutria and beaver) seem to be attracted by red and orange colors. It is especially important to mark rows when acorns are direct seeded, because newly germinated seedlings are extremely difficult to find in dense cover for the first 3 or 4 years after germination. There have been several cases where areas planted with acorns were initially thought to be failures following sampling after the first growing season.

However, subsequent sampling, after several years when the young seedlings had grown to sufficient size to be more easily seen, revealed that the plantings were actually a success.

4. When fields are not planted in rows (e.g., aerial seeding of acorns, broadcast spreading, natural invasion), circular or rectangular plots can be used to obtain a 2 percent sample. For example, if the planted area is 100 acres and a rectangular plot size of 100′ X 15′ is used, then 59 sample plots of this size are needed to achieve a 2 percent sample. For long-term scientific purposes, mark plots permanently (e.g., magnetic markers buried underground).

5. When plots are used, randomly locate sample plots according to existing terrain. For example, if the terrain and environmental conditions (e.g., hydrology, soil types) of the area to be planted are mostly homogeneous, plots can be located randomly along the planting rows. If the terrain and environmental conditions vary in a recognized manner over the area, the different zones should be delineated, and a sampling scheme that includes representative samples across all identified zones should be implemented. Data should be evaluated separately according to the various zones identified.

6. Sampling for germination and survival is best done during the fall and early winter, when the leaves have changed color and other vegetation is dying.

7. Count all tree species encountered within a sample plot. Both the species planted and the natural invaders will comprise the future forest ecosystem. The species information to be obtained about natural regeneration is critical to understanding succession and species-site relationships.

8. All bottomland reestablishment projects should have a required follow-up monitoring plan included as an integral part of the total project cost.

Research Needs: There are numerous interacting environmental factors that may affect the germination, growth, and survival of both planted and naturally invading species. Accordingly, there has been considerable research conducted relative to the reestablishment of bottomland forest species as influenced by many different environmental conditions (e.g., Haynes, Allen, and Pendleton 1988). However, there is a continuing need for additional repetitive studies to help validate the results and conclusions derived from previous studies. Furthermore, there is a great need for more research on natural succession and species diversity on both planted and unplanted areas. These studies should span a longer period of time than the 3- to 5-year follow-up monitoring studies often associated with projects and then forgotten over time. Most researchers recognize these long-term study needs, but find it difficult, if not impossible, to obtain a project funding commitment past 3 to 5 years.

The Service has recently increased its efforts to obtain scientific information about the restoration of bottomland forest ecosystems. For example, field project leaders have been encouraged to conduct follow-up monitoring of their planting operations and to maintain marked plots for future studies. One cooperative study involving the Service, Soil Conservation Service, Environmental Protection Agency, and the Louisiana Forestry Commission began in 1992 and will continue at least through 1995. This study is being carried out by the Louisiana State University Cooperative Fish and Wildlife Research Unit, and will evaluate various reforestation methods used under a number of site conditions and treatments. A similar study on a large tract (about 2,600 acres) of abandoned agriculture land (i.e., prior-converted cropland and farmed wetland) in Mississippi, involving the Service and other Federal and State agencies and the forest industry, is currently being planned for implementation during 1994. Also, the Service's National Wetlands Research center in Lafayette, Louisiana, began a research initiative that focuses on the reestablishment and biodiversity of bottomland forest ecosystems. Other Federal agencies such as the Corps of Engineers (e.g., Waterway Experiment Station, Vicksburg, Mississippi), Environmental Protection Agency, Soil Conservation Service, and U.S. Forest Service (e.g., Southern Forest Experiment Station, Stoneville, Mississippi) are also continuing or increasing their research efforts on bottomland forest ecosystems.

CONCLUSION STATEMENT: Since 1988, the Service has planted over 30,000 acres of bottomland tree species on previously cleared lands within the LMRAV. The Service also plans to plant an additional 20,000 acres over the next 5 years. Although much information has been obtained, there is still much more to be learned. Many of the Service's plantings have been judged to be a success; others have failed for many different reasons. These failed attempts have been or will be replanted. Much of the information gained has been through trial and error methods; thus, we continue to learn from our mistakes, as well as from the work carried out by others.

We believe that a significant philosophical bridge has been crossed over the past 8 to 10 years. That is, we have moved ahead from the period of documenting the significant losses of bottomland forest ecosystems, and the Federal subsidizing of the drainage and clearing of these ecosystems, to an era where many influential parties (government, nongovernment environmental groups, private citizens, industry, and others) now clearly recognize the wide-ranging significance and economic importance of our bottomland forests. Many of these parties are now dedicated to restoring bottomland forest ecosystems whenever and wherever opportunities are found. Many new and innovative ideas are being generated to encourage landowners to protect and conserve these forest systems.

LITERATURE CITED

Allen, J.A. 1990. Establishment of bottomland oak plantations on the Yazoo National Wildlife Refuge Complex. Southern Journal of Applied Forestry, 14(4): 206-210.

Allen, J.A. and H.E. Kennedy, Jr. 1989. Bottomland hardwood reforestation in the Lower Mississippi Valley. U.S. Fish and Wildlife Service, National Wetlands Research Center, Lafayette, Louisiana, and U.S. Forest Service, Southern Forest Experiment Station, Stoneville, Mississippi. 28 pp.

Burns, R.M. and B.H. Honkala. 1990. Silvies of North America. Vol. 2, Hardwoods. U.S. Forest Service, Agric. Handbook 654. Washington, D.C. 877 pp.

Clark, J.R. and J. Benfirado (eds). 1981. Wetlands of bottomland hardwood forests. Proc. of a workshop, Lake Lanier, Georgia, June 1-5, 1980. Developments in Agricultural and Management - Forest Ecology 11. Elsevier Scientific Publishing Company, New York. 402 pp.

Haynes, R.J. 1992. Partners for wildlife and related wetland initiatives on private lands. Proc. 13th Annual Meeting, Society of Wetland Scientists, New Orleans, Louisiana (In Press).

Haynes, R.J., J.A. Allen, and E.C. Pendleton. 1988. Reestablishment of bottomland hardwood forests on disturbed sites: An annotated bibliography. U.S. Fish and Wildlife Service. National Wetlands Research Center, Biological Report 88(42). Slidell, Louisiana. 104 pp.

Haynes, R.J. and L. Moore. 1988. Reestablishment of bottomland hardwoods within national wildlife refuges in the southeast. Pages 95-103 In: National Wildlife Federation -- Corporate Conservation Council: Proc. of a Conf.: Increasing our Wetland Resources. National Wildlife Federation, Washington, D.C.

Hefner, J.M. and T.E. Dahl. 1993. Current forested wetland systems in the Southeast Region. U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia (In Press).

U.S. Congress. 1990. Food, Agriculture, Conservation, and Trade Act of 1990. Public Law 101-624. U.S. Congress, Washington, D.C.

U.S. Congress. 1987. The Agricultural Credit Act of 1987. Public Law 100-233. U.S. Congress, Washington, D.C.

U.S. Congress. 1985. The Food Security Act of 1985. Public Law 100-233. U.S. Congress, Washington, D.C.

U.S. Department of Agriculture. 1993. 1992 Wetlands Reserve Program: Report to Congress. U.S. Department of Agriculture, Washington, D.C.

U.S. Department of Agriculture. 1991. Title XIV -- Conservation Part 1 -- 1985 Food Security Act, as amended by subtitles A-C of Title XIV. Title XII -- Conservation. U.S. Department of Agriculture, Washington, D.C. 95 pp.

U.S. Fish and Wildlife Service. 1986. North American waterfowl management plan. U.S. Fish and Wildlife Service, Washington, D.C. 19 pp.

Wharton, C.H., W.M. Kitchen, E.C. Pendleton, and T.W. Sipe. 1982. Ecology of bottomland hardwood swamps of the southeast: A community profile. U.S. Fish and Wildlife Service, Biological Services Program: FWS/OBS 81/37. 134 pp.