CYPRESS SWAMP REGENERATION:
A RECLAMATION ALTERNATIVE FOR WET DEPRESSIONS IN CLAY SETTLING PONDS

Betty T. Rushton
Center for Wetlands, and
Dept. of Environmental Engineering Sciences
University of Florida
Gainesville, Fl 32611

ABSTRACT

Several thousand baldcypress, (*Taxodium distichum*), seedlings were planted on phosphate clay settling ponds, a by-product from phosphate mining. Experimental plots were established during the drought winter of 1984-85. Treatments included cleared plots and those with dense vegetation as well as different seedling type, bareroot vs. tubelings. Except for the most severly flooded sites, survival was between 55 and 77% depending on reclamation methods. Drought and unsuitable water levels were the major cause of mortality. Grazing by wildlife stunted many of the trees. There was no significant difference in percent survival or height of trees between plots cleared of all above-ground vegetation at time of planting and those left uncleared ($P > 0.05$). Bareroot seedlings planted in the spring were more successful than tubelings planted during the winter ($P < 0.05$). Initial success with planted tree seedlings indicate clay settling ponds present suitable conditions for the establishment of baldcypress.

INTRODUCTION

A study of succession on clay settling ponds showed vegetation colonized along an environmental gradient (Rushton 1983, Rushton 1984). Drier locations were often dominated by bottomland hardwood species, while wet depressions were characterized by shrubby willow, (*Salix caroliniana*), species. It was hypothesized these wet areas were suitable for cypress-gum ponds but the seeds were unable to reach the site.

The purpose of the present project was to break arrested willow succession by planting species common to cypress forests. Experimental transects were designed to test several theories. 1) To determine the role of hydroperiod, seedlings were planted along an environmental moisture gradient. 2) To understand the role of competition, half the plots were cleared of all existing above ground vegetation in some of the experiments. 3) To see if nursery practices have an effect both bareroot and tubelings were used in paired experiments. 4) To compare various reclamation, disposal, and mining techniques on tree success, different clay settling ponds were used.

Clay settling ponds are a by-product of phosphate mining, a major industry in central Florida. Typically one ton of clay waste (dry weight) is produced for each ton of phosphate rock. The clays expand to many times their original volume in the mining process and require large above-ground storage impoundments ranging from 160 to 325 ha. surrounded by earth dams from 7 to 20 meters in height. Approximately 50 to 70% of the land proposed for mining is designated for clay settling areas. Reclamation of clay impoundments is mandated by Florida state law, which requires restoration of all lands disturbed by phosphate mining after July 1, 1975. Since phosphatic clays have poor load bearing capacity, possibilities for productive use following mining are limited. Most reclamation projects have converted clay ponds to pasture.

In Florida, a state with a long colorful history of drainage projects, interest in saving wetlands has increased steadily over the past decade culminating in the passage of the Warren S. Henderson Wetland Protection Act of 1984. Mitigation by restoration of wetlands could replace swamps being lost by current and past land use practices. Cypress swamps, which occur throughout the southeastern United States, are especially common in Florida, where they form lake fringes, strands, and domes. Clay settling ponds provide an opportunity to restore cypress forest to the post mining landscape.

STUDY SITES

Seven clay settling ponds representing different ages and reclamation techniques were planted during the winter of 1984-85. The locations are shown on the map in Fig. 1 and summary information is listed in Table 1.

CF Industries used a sand/clay mix for clay disposal at their Hardee mining complex. This site was abandoned as an active clay pond in 1983. Trees were planted along the edge of a seasonally flooded pond.

Gardinier, Area A, located at the Ft. Meade mine was ditched, drained, and the dikes lowered in 1975. Outfall pipes are now above the level of the clays providing drainage only during extremely high water. Trees were planted in the wetter lower end which had been submerged for the past year. During the early establishment phase, however, a drought and subsequent fire caused considerable mortality.

Tenoroc, Area 4A, is a large clay settling pond located in a State Reserve under the jurisdiction of the Dept. of Natural Resources. The west end, where most of the trees were planted was mined and has many spoil piles protruding above the clay surface. Three transects are located on the edge of an intermittent pond. Four drier transects were planted in willows growing at the northwest corner.

IMC-H9 is a reclamation project for International Mineral & Chemical Corp. In 1985 it already had healthy, well established 4-5 year old cypress and other hardwood trees. It represents one of the first wetland reforestation efforts on clay settling ponds. The clay pond was deactivated about 1970 and capped with sand tailings about 1979. Two transects were in a willow forest adjacent to a lake and two were planted in the lake.

The Mobil site is a pasture pond located south of Highway 640 near

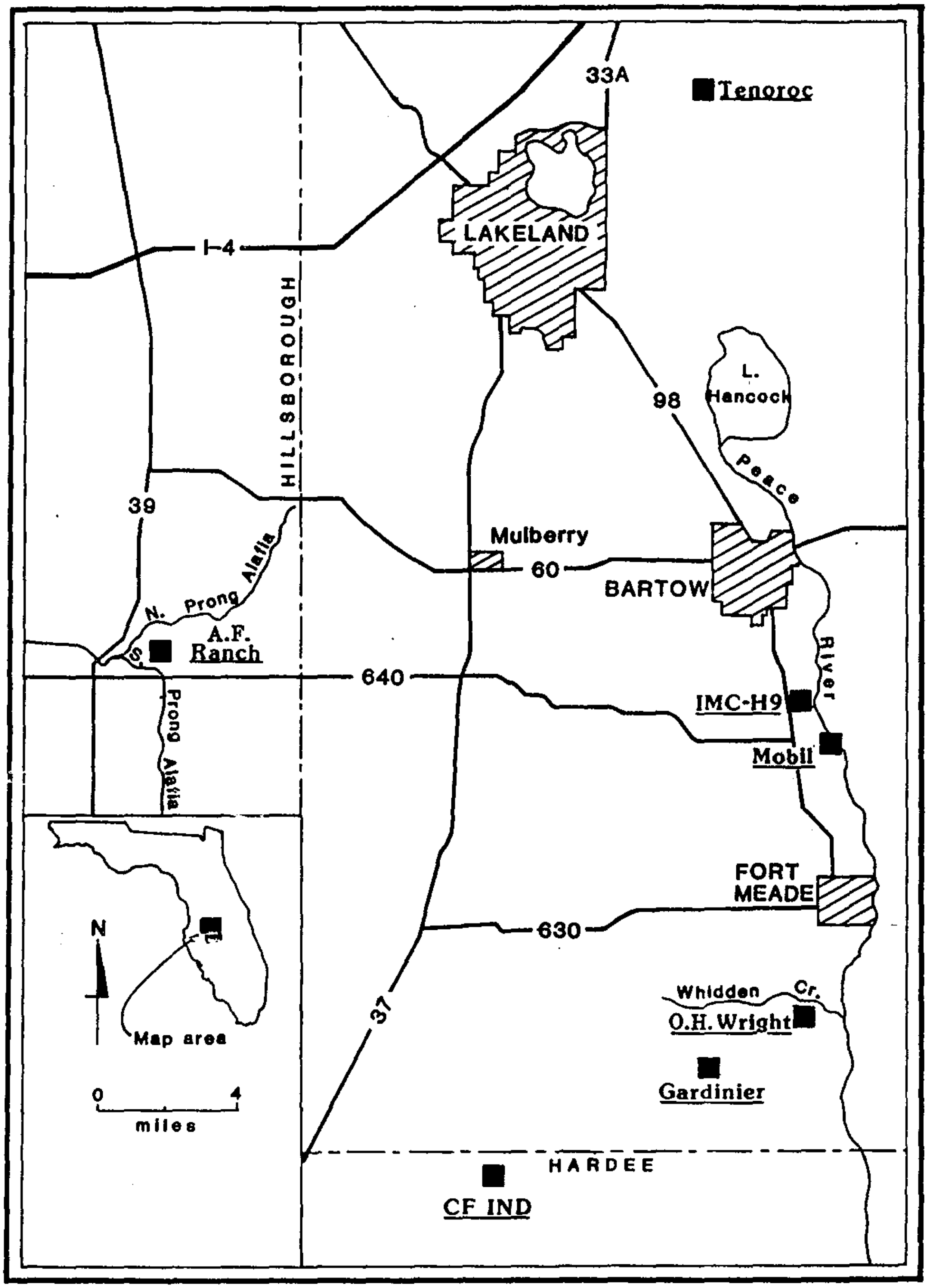


Figure 1. Location of study sites.

TABLE 1. Study site summary information.

SITE	ABANDONED (EST)	RECLAIMED (EST)	MINED	PRESENT USE	OWNER	LOCATION	Δ TREES PLANTED	DATE PLANTED
A.F.RANCH	1950	NONE	NO	PASTURE	C.L.KNIGHT	T30S,R22E SECTION 1	186 248	FEB 1985 TB* MAR 1985 BR**
O.H.WRIGHT	1955	NONE	YES	NATURAL	GARDINIER FT. MEADE	T32S,R25E SECTION 9	186 186	DEC 1984 TB MAR 1985 BR
GARDINIER AREA A	1973	1975 DITCHED	NO	NATURAL	GARDINIER FT.MEADE	T32S,R24E SECTION 2	558 310	OCT 1984 TB MAR 1985 BR
TENOROC ZONE 4A	1972	NONE	YES	NATURAL	FLORIDA DEPT. NATURAL RES.	T27S,R24E SECTION 2	248 248	NOV 1984 TB MAR 1985 BR
CF INDUSTR SP-1	1983	SAND/CLAY MIX	YES	RECLAIM PROJECT	CF INDUSTRIES HARDEE	T33S,R24E SECTION 7	186	MAR 1985 BR
MOBIL HOMELAND	1960	1975 SAND CAP	YES	PASTURE	MOBIL	T31S,R25E SECTION 3	248	MAR 1985 BR
IMC H9	1970	1979 SAND CAP	YES	RECLAIM PROJECT	INTERNATIONAL MINERALS CORP.	T30S,R25E SECTION 33	248	MAY 1985 BR

* TB TUBELING
** BR BAREROOT SEEDLING

Homeland. The clay settling pond has been capped with sand tailings. At least part of the site had been mined before clays were deposited. Seedlings were planted in a small shallow lake that seldom goes dry. Soil at the surface in the transects was 100% sand.

Alderman Ford Ranch is an older clay settling pond located above the confluence of the north and south prongs of the Alafia River. Aerial photographs show the site being filled with clay in 1948. Twelve seedling transects were planted in two swales which were known to be periodically flooded. One was colonized by maples and oaks, the other by willows.

O. H. Wright, owned by Gardinier, is located adjacent to the Whidden Creek floodplain. It is an old surface mine backfilled with clay. Aerial photographs from 1957 show the mine cuts being filled. Some transects were located in a periodically flooded low area while others were in drier narrow mine cuts.

METHOD

Replicate elongated quadrats (4-m X 30-m) were established through an environmental gradient from dry to wet where possible. One hundred transects with 93 trees each were planted with a KBC planting bar. Seedlings were arranged in 3 columns on 1-m centers and one of 3 species was randomly assigned to each column. In paired experiments, the tree order was duplicated. This paper discusses the fate of 3,000 baldcypress (Taxodium distichum), planted during the winter of 1984-85. See Table 1 for planting dates. Survival and tree height were measured in April 1986 approximately one year after planting. Water table was measured in October 1985 by digging down to water when it was below the surface and measuring the depth when it was above the surface. An estimate of water table depth was made for each tree using elevations taken with a level and stadia rod. This gives a relative moisture measurement for one point in time for each seedling.

Two types of seedlings were used. Tubelings were grown by Pete Wallace's Nursery, Rt 1 338F, Gainesville, Fla 32608, and maintained in a shade house until planted. Tubelings were grown in styrofoam or plastic flats with dividers. The soil was a good potting medium. Bareroot seedlings came from the Division of State Forestry at Chiefland. They were grown in the ground from seed, fertilized at planting time with one or two more top dressings applied during the growing season. Seedlings were approximately one year old when pulled from the ground, tied into bundles, and kept in a cooler at 4°C until planted. The time of storage ranged from several days to several months. The 1,178 tubelings were pruned to 50 cm tall when planted. There was a wide range of sizes (30 to 80 cm) for the 1,674 bareroot seedlings . Paired plots at 4 clay settling ponds were used to compare seedling types.

To understand the role of competition from existing vegetation, other paired plots were planted with one of each pair cleared of all above ground vegetation with a machete, bank blade, or chain saw. Three clay settling ponds were used for these experiments.

Statistics were performed using the Statistical Analysis System (Ray 1982). For both the paired plot experiments seedling type

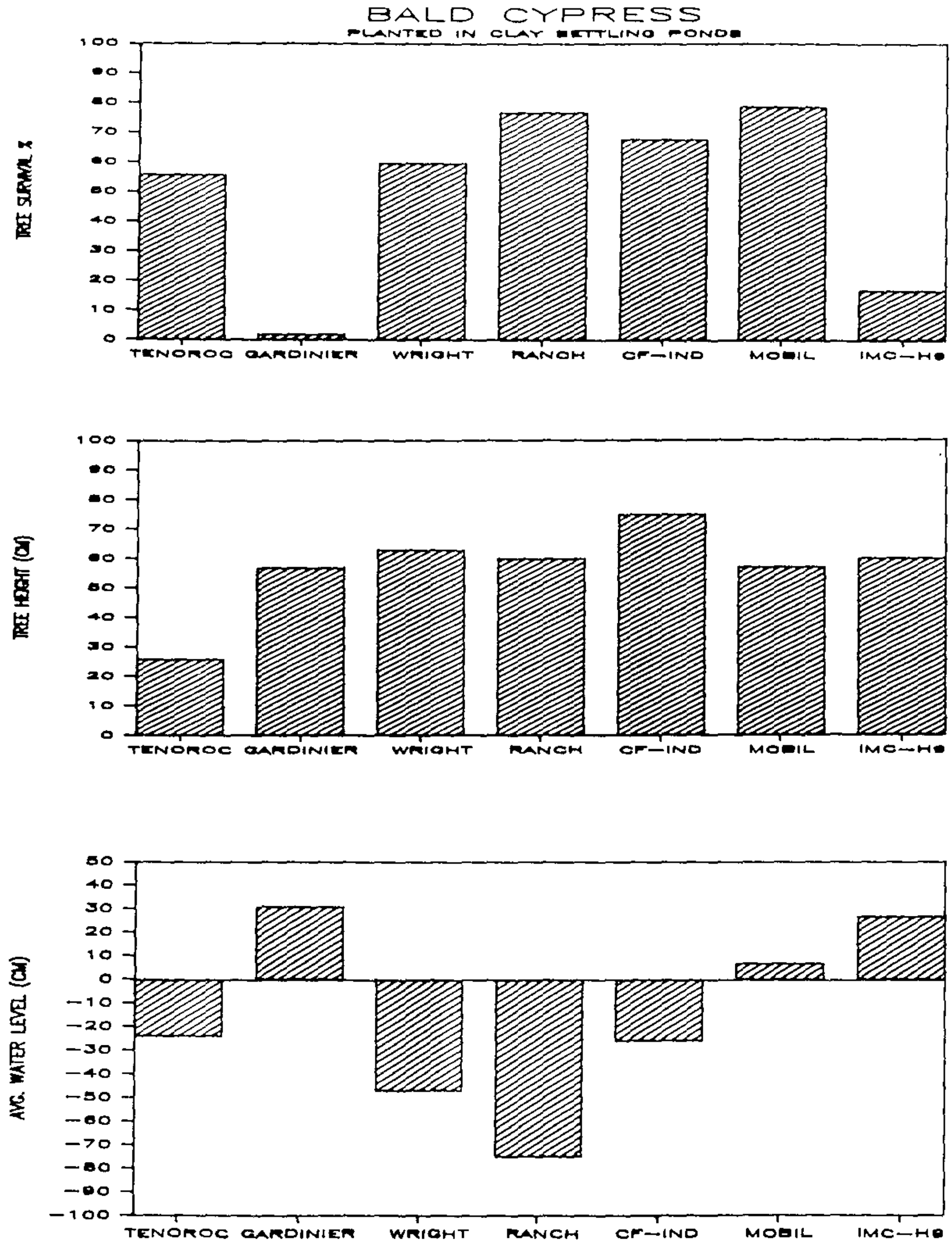


Figure 2. Comparison of baldcypress, (Taxodium distichum), bareroot seedlings planted in 7 clay settling ponds. Counts and measurements for trees were made one year after planting. Depth to water table was an average of th 1985-86 growing season.

(bareroot vs. tubeling) and competition (cleared vs. uncleared) the same statestical methods were used. Significance tests of frequencies for survival data were determined using the chi-square test. A t-test for the difference between two means analyzed height data.

RESULTS

COMPARISON BETWEEN SITES:

Bareroot seedlings were planted at all seven sites in March 1985, except for IMC-H9 which was planted in May. Average survival, height, and depth to water table for each clay settling pond are compared in Figure 2. Two sites had very poor survival, Gardinier and IMC-H9, 8 and 16% respectively. They also exhibited widely fluctuating water tables. Although dry when planted, both flooded during the summer rains and still had an average water depth over 40 cm in Oct. 1985. Trees at IMC-H9 were planted during the May drought of 1985, one of the worst on record, and immediately grazed by animals which were believed to be rabbits. Most trees were not tall enough to escape inundation when the rains arrived in June. At Gardinier the drought and fire had killed all but 30% of the trees, most of which were recovering as basal sprouts. When the rains came, flooding killed all but the tallest fire survivors.

The remaining sites had from 55 to 77% survival of baldcypress bareroot seedlings after one year. Average water table depth below the surface didn't appear to have a detrimental affect on tree survial. Seventy-seven percent of the trees were alive at Alderman Ford Ranch where the water table is the lowest. The sand/clay mix used by CF Industries may enhance tree growth. Some of the tallest trees (average 75 cm) were found there with 68% survival. The Mobil pasture pond where seedlings are growing in sand tailings had a high survival (79%) and an average height of 57 cm. Poorer survival (56%) and growth (avg. 32 cm) at Tenoroc may be attributed to heavy grazing by wildlife. The older sites O. H. Wright and A. F. Ranch, 25 and 35 years since deactivated respectively, didn't have any better growth and survival than younger sites. This is especially true when the post disposal history included adding sand to the clays.

TUBELINGS VS BARE ROOT SEEDLINGS:

Except for Gardinier, bareroot seedlings survived better than tubelings in paired plot experiments (Fig 3.). There was a significant difference in survival at all sites (Table 2). There was also no significant difference in growth measured after one year ($P>.05$). At Gardinier the bareroot seedlings were planted less than one month before a fire which especially affected the newer seedlings.

CLEARED VS UNCLEARED TRANSECTS:

Clearing plots of all above-ground vegetation at time of planting produced no significant difference in survival (Table 2) at any of the sites (Fig. 4). There was no significant difference in height of

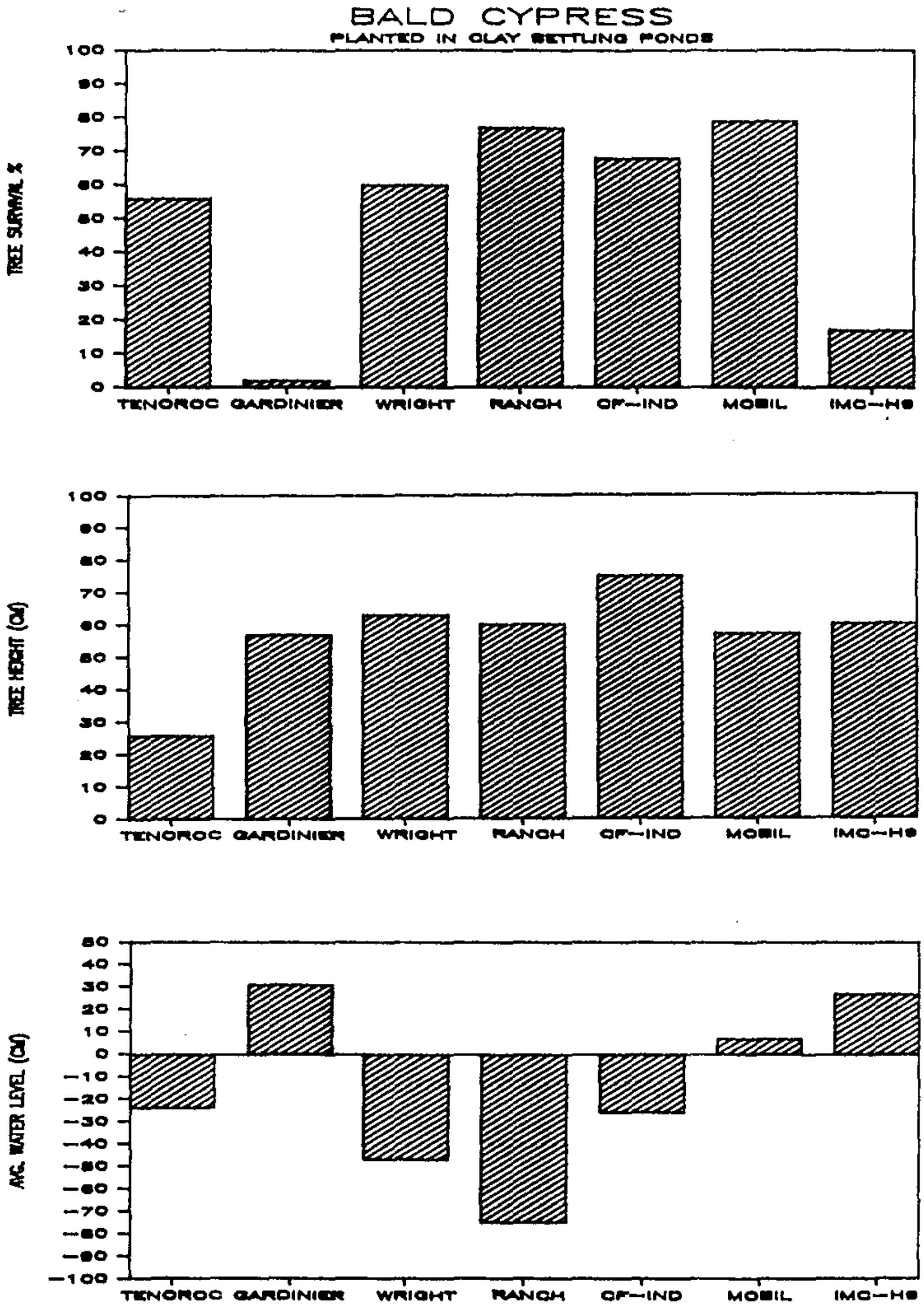
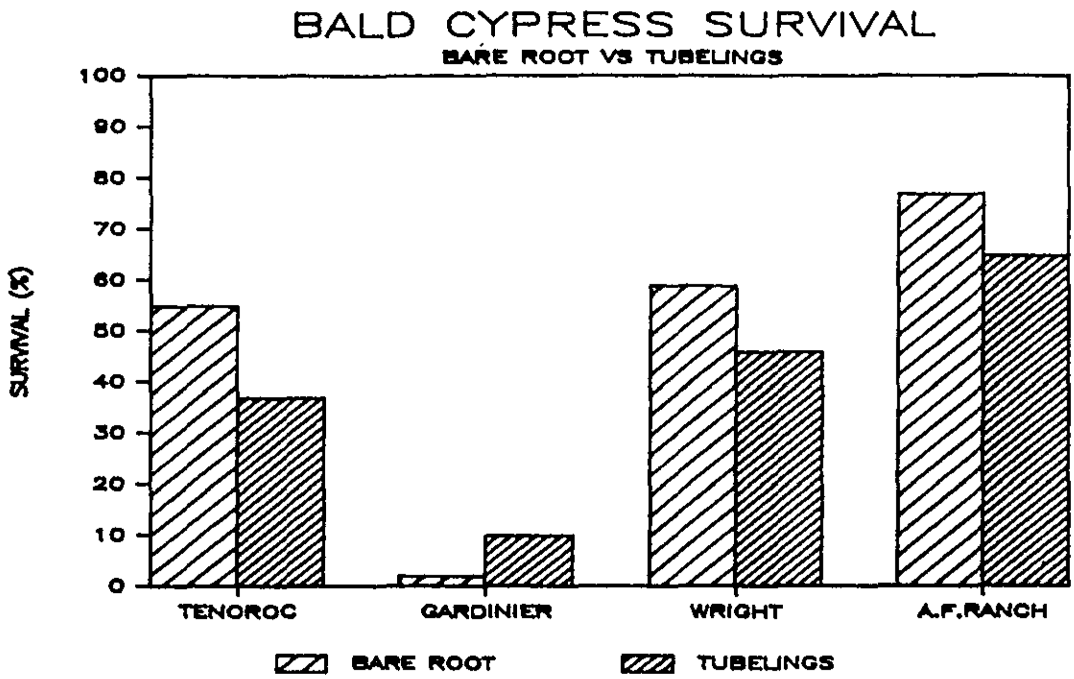


Figure 2. Comparison of baldcypress (<u>Taxodium distichum</u>) bareroot seedlings planted in seven clay settling ponds.



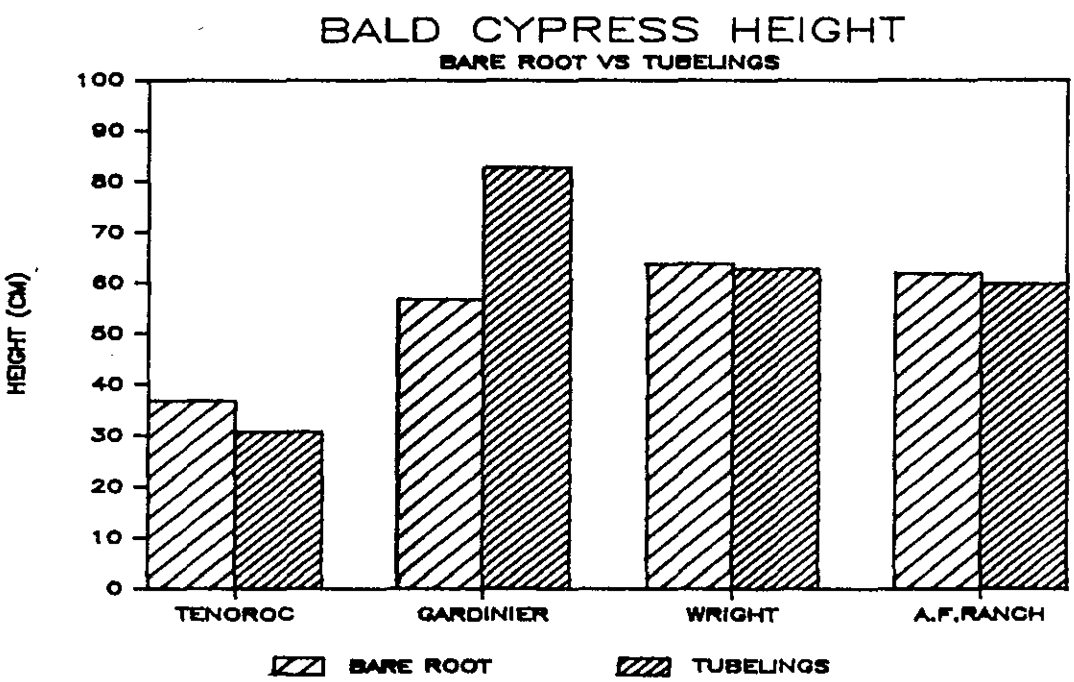
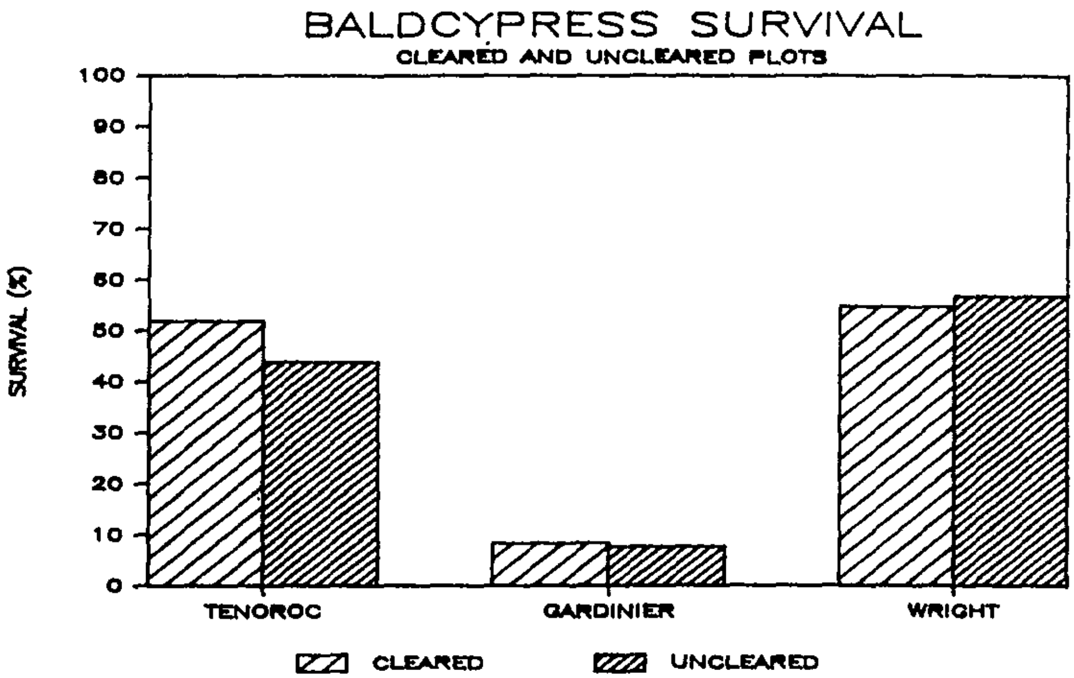


Figure 3. Baldcypress (*Taxodium distichum*) bareroot seedlings planted in the spring compared to tubelings planted in the winter of 1984-85 after one year of growth.



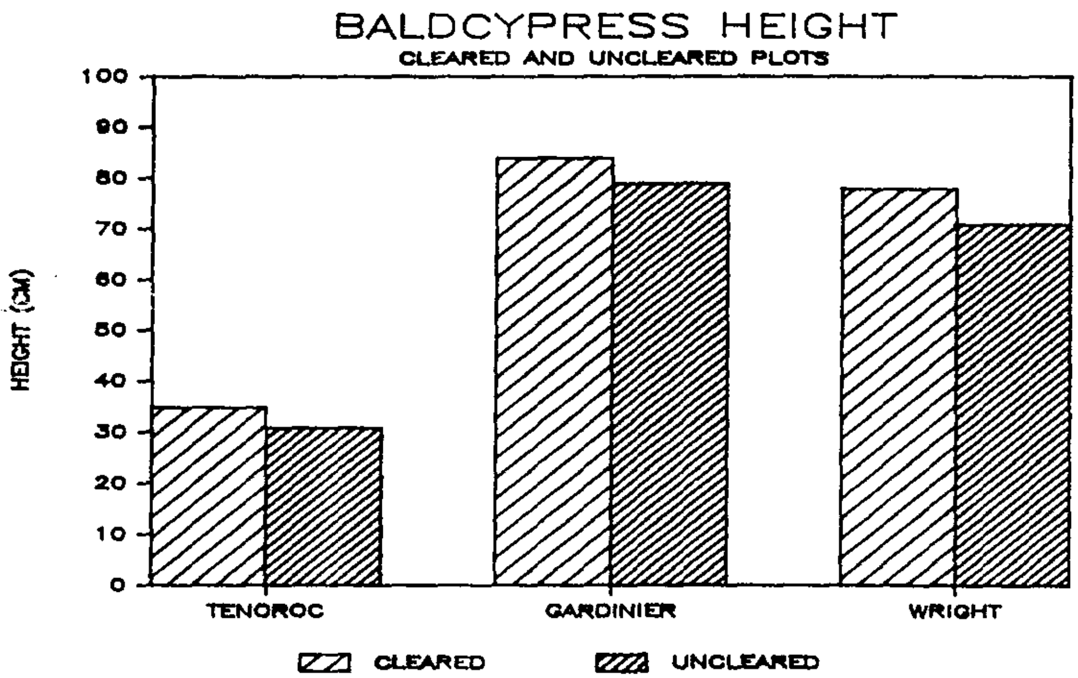


Figure 4. Baldcypress (*Taxodium distichum*) planted in cleared and uncleared plots after one year of growth.

Table 2. Chi-square distribution for survival of baldcypress seedlings after one year of growth.

Tubelings vs. Bareroot Seedlings:

Site	Df	Chi-square	Probability
Tenoroc	1	9.310	P=0.002
Gardinier	1	13.467	P=0.000
Wright	1	4.885	P=0.027
A. F. Ranch	1	5.687	P=0.017

Cleared vs. Uncleared Transects:

Site	Df	Chi-square	Probability
Tenoroc	1	2.952	P=0.086
Gardinier	1	0.105	P=0.746
Wright	1	0.053	P=0.818

trees after one years growth ($P>.05$) except at Tenoroc which was significant at the $P=0.04$ level. The cleared transects were rapidly recolonized by vines and herbaceous vegetation. Where trees were present and removed they produced abundant basal sprouts. Clearing of plots removed the canopy but increased competition from the herb layer.

DISCUSSION

WATER DEPTH:

Cypress (Taxodium distichum) planted in experimental transects demonstrated an amazing ability to survive, considering they were purposely planted over a wide moisture gradient. Water levels included land flooded 1-m deep to water tables 1.8-m below the surface when measured in October 1985. A severe drought during the growing season caused the greatest mortality. Many trees were stressed during the winter from lack of water only to be drowned during the summer rainy season. Both Gardinier and IMC-H9, flooded for the past year, had the poorest survival. Once established cypress can exist on anaerobic soils where water is present on a near permanent basis (Harms et al. 1980). However, cypress seedlings are unable to tolerate complete flooding for longer than two weeks (Demaree 1932), and can be killed by submergence for as little as two to three days (Williston et al.1981). Even seedlings that escaped complete inundation on the flooded sites were not as tall or healthy as those growing on sites that are periodically underwater. This is consistent with other studies. Cypress growth rate was shown to be greatest where the average water table was between 0 and 15 cm for trees planted in a nearby phosphate reclamation project (Best and Erwin 1984).

Mean water depth appears to be a controlling factor for cypress dominance. Marois and Ewel (1983) found cypress importance values from unaltered wet domes were significantly higher than for drained drier domes which showed increasing invasion from other tree species. Stalter (1981) also cited competition from bottomland hardwood species as a major deterent to baldcypress survival on drier sites. Cypress is an early colonizer on alluvial land but gives way to bottomland hardwoods where water is gradually receding (Williston et al. 1981).

If clay settling ponds are to be managed for cypress, water level control will be an important tool. However, if diverse bottomland hardwood forest is a desired goal, the best course is to select plant species from a range of communities as recommended by the Florida Game and Fresh Water Fish Commission (King, et al.1985). This plan would increase species richness which is inversely proportional to flooding frequency (Connor and Day 1976).

COMPETITION:

Cypress trees can endure partial shading but require considerable sunlight for normal growth. Early cypress plantations in Louisiana failed because of shading by plant competition (Williston et al. 1981). Forest industries routinely employ varying degrees of site preparation to insure better survival and increase growth rates. For success, however, most studies indicate cultural treatments have to be intensive and continue for several years. For example, there was no statistical difference between mowed plots and controls for several species of bottomland hardwood trees. But periodic disking significantly increased heights, diameters, and survival (Kennedy 1981, Hunt and Cleveland 1979, Krinard and Kennedy 1983). Davies (1985) observed cutting weeds above ground level is ineffective. He further stated moisture deficits increased the detrimental conseqences of root competion.

Other alternatives require no pre-treatment. Reforestation of surface mined lands can be planned to maximize wildlife diversity (McComb 1982, King et al. 1985). Understory vegetation, anathema for the forest industry, is positively correlated with density of small mammals (Greier and Best 1980), provides additional browse for deer (Murphy and Ehrenreich 1965), and increases songbird diversity (MacArthur and MacArthur 1961). Wildlife of this kind has been observed in the study sites.

Competition from vines is part of the ecological complex in bottomland forest. Tree species vary in their reaction, but with good stocking, stands usually outcompete vines when dominants are 5 to 7 meters tall (Johnson 1975). Some trees respond by sending out new lateral shoots, others overcome the vines by sheer size and numbers. Forests on surface mines in the central states were established successfully by planting trees in pre-existing ground cover over 30 years ago (Ashby et al. 1980). Natural invasion of trees was also far greater on reforested areas than on adjacent unplanted lands on these coal strip mined sites.

The purpose of a reclamation project should be assessed before extensive alteration of the site is attempted. Because of "soupy" clays several years are required before decommissioned ponds can be reclaimed. In the meantime the sites are naturally revegetated with early successional species such as cattails and willows. It may be necessary to drain, grade, and recontour clay settling ponds for specific uses or to blend into the surrounding landscape. But if existing vegetation survives reclamation, the seedlings in this project demonstrated comparable growth and survival when plots were left uncleared and in the meantime existing vegetation continued to function as good wildlife habitat. In fact, a serious impediment to tree survival was grazing from rabbits, rats, and deer.

NURSERY STOCK TYPE:

Woody plant seedlings grown in a greenhouse extend the planting season for reforestation as well as provide greater species selection. Bareroot plant stock is cheaper and easier to transport. Which is better? In this experiment, bareroot seedlings showed significantly better survival than tubelings grown in styrofoam flats. This is not always the case. In Pennsylvania survival of container-grown plants was no better than bareroot seedling planted in Spring (Vogel 1981). Bareroot seedlings had poorer survival when planted in March and about the same survival when planted in April, compared with paperpots, peat stick, and gro-blocks (Barnett and McGilvray 1981). Survival of container and bareroot stock was similar for red pine (Pinus resinosa), but spring-planted bareroot stock had significantly greater survival than stock planted in the fall (Marion and Alm 1986).

Bareroot stock made it possible to plant cheaper trees in this experiment. It's not clear if greater survival of bareroot seedlings was the result of spring planting or nursery stock type. Tubelings planted during the winter had to endure a major drought and freeze which contributed to the demise of many area orange groves.

CONCLUSIONS:

New rules for mitigation and reclamation increase the importance of understanding species tolerance and survival to properly reclaim mined lands. Results from the first year of data indicate cypress trees may be suitable for wet depressions of clay settling ponds. Additional research about nutrients, nurse crops, soil amendments and time of planting should point the way to increasingly successful full scale projects.

ACKNOWLEDGEMENTS

Work was supported by contract 83-03-041R between the Florida Institute of Phosphate Research and the Center for Wetlands, University of Florida, H. T. Odum and G. R. Best, Principal Investigators. A student cooperative program between the University of Florida and the Florida Bureau of Land Reclamation increased the scope of the project. Tim King of Florida Game and Freshwater Fish Commission was indespensible in locating sites. Cooperation from property owners and mining companies listed in Table I is appreciated. Tree planting was assisted by M. Miller, C. Bersok, J. Feiertag, C. Pezeshki, R. Arrieta, C. Irwin, P. Wallace, R. Wolfe, R. Hassoun and especially Alfonso Hernandez and his family. J. Ley and S. Tennenbaum helped with determining elevations. B. Sargent installed wells. S. Swank and D. Cronwell measured trees. Jim Feiertag explained statistics and SAS. D. Segal and C. Bersok edited copy.

REFERENCES

Ashby, W. C., C. A. Kolar, and N. F. Rogers. 1980. Results of 30-year-old plantations on surface mines in the central states. In Trees for reclamation. Interstate Mining Compact Commission and U. S. Dept. of Agriculture. GTR NE-61.

Barnett, J. P. and J. M. McGilvray. 1981. Container planting systems for the south. Southern Forest Experiment Station. U. S. Dept. of Agriculture. Research Paper SO-167.

Best, G. R. and K. L. Erwin. 1984. Effects of hydroperiod on survival and growth of tree seedlings in a phosphate surface-mined reclaimed wetland. In Symposium on surface mining, hydrology, sedimentology, and reclamation. University of Kentucky, Lexington, Ky 40506-0046. December 2-7.

Conner, W. H., and J. W. Day, Jr. 1976. Productivity and composition of a baldcypress-water tupelo site and a bottomland hardwood site in a Louisiana swamp. Am. J. Bot. 63:1354-1364.

nd the use of tree
ass-dominated

ium. Ecology

ion by small mammals
habitat alterations.

rown, and F. W.
n the swamp forest in
-1421.

ments affect growth,
and loblolly pine.
5-59.

evelopment of nuttall
st Experiment Station. U.
O-104.

centrations and hardwood
. Plant and Soil 63:307-

abitat reclamation
vices. Florida Game and
la.

Ten-year growth of five
l weed control on Sharkey
. Station. U. S. Dept. of

1. On bird species

ral and management-related
Sci. 29(3):627-640.

ormance of fall- and spring-
n red pine. Tree Planters'

habitat management in central
80(8):490-492.

65. Effects of timber harvest
roduction. J. Wildl. Manage.

Ray, A. A. 1982. SAS users guide:Statistics. SAS Institute Inc. Cary, N.C.

Rushton, B. T. 1983. Examples of natural wetland succession as a reclamation alternative. In Reclamation and the phosphate industry. Robertson, D. J. (Ed). Florida Institute of Phosphate Research. Bartow, Fla.

Rushton, B. T. 1984. Natural wetland regeneration in clay settling ponds. In Proceedings of the eleventh annual conference on wetland restoration and creation. Hillsborough Community College Environmental Studies Center. Tampa, Fla.

Shelford, V. E. 1954. Some lower Mississippi Valley flood plain biotic communities: Their age and elevation. Ecology 35(2):126-142.

Stalter, R. 1981. Some ecological observations of Taxodium distichum(L.) Richard, in Delaware. Castanea 46(2):154-161.

Vogel, W. G. 1981. A guide for revegetating coal minesoils in the eastern United States. General Technical Report NE-68. U. S. Dept. of Agriculture.

Williston, H. L. , F. W. Shropshire, and W. E. Balmer. 1981. Cypress Management: A forgotten opportunity. U. S. Dept. Agric., For. Serv., Forestry Rep. SA-FR-8, Atlanta, Ga.