SIXTH-YEAR RESULTS FOLLOWING PARTIAL CUTTING FOR TIMBER AND WILDLIFE HABITAT IN A MIXED OAK-SWEETGUM-PINE STAND ON A MINOR CREEK TERRACE IN SOUTHEAST LOUISIANA

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Abstract—Hardwood management has primarily focused on highly productive river bottom and upland sites. Less is known about hardwood growth and development on terrace sites. Such sites are usually converted to other uses, especially pine plantations. The objectives of this study, implemented in a minor creek terrace in southeast Louisiana, were to describe changes in stand composition and structure following partial cutting for 3 different management objectives: (1) maximize timber production, (2) maximize wildlife habitat, and (3) to improve timber production and wildlife habitat. Stand composition in 1985 prior to treatment was heavy to oak (72 percent based on importance values) compared to sweetgum (10 percent) and pine (16 percent). Greater diameter growth occurred in the treated plots compared to control 6 years after cutting. Diameter growth differences were also found between crown classes and species groups. Few differences were found in basal area growth between the treatments and the controls while stocking in the treated plots increased relative to the controls. Results indicate that hardwoods will respond to partial cutting on terrace sites, making hardwood or mixed pine-hardwood management options viable.

INTRODUCTION

Bottomland hardwood forest cover types (oak-gum-cypress and elm-ash-cottonwood) cover about 34 percent, or 4.7 million acres, of Louisiana's forested land based on the last U.S. Forest Service state forest inventory (Vissage and others 1991). Combined with the upland hardwood types (oak-hickory and oak-pine), hardwood-dominated forests cover 8.7 million acres or 63 percent of Louisiana's forested land (33 percent of Louisiana's total land base; Vissage and others 1991). Current hardwood acreage estimates are unknown. While land clearing for agriculture has continued, especially in the Mississippi Alluvial Plain, the rate of clearing has slowed. Furthermore, the trend to clear hardwood forests for agriculture may have been offset or even reversed since the last forest survey due to land being replanted to hardwoods, primarily under the Conservation Reserve Program and the Wetlands Reserve Program (Stanturf and others 1998). The vast acreage dominated by hardwood species, combined with the value of quality hardwood for both timber and wildlife habitat, attests to the tremendous opportunity for hardwood management in Louisiana, especially when one considers that hardwood lumber production accounted for only 1.91 million bf of the 1.148 billion bf harvested in Louisiana in 1999 (based on severance tax collections; Louisiana Office of Forestry web site - http://www.ldaf.state.la.us/forestry/index.htm).

Hardwood management in the southern United States has focused either on bottomland sites, especially first bottoms (Putnam and others 1960, Walker and Watterston 1972, Kellison and others 1981), or upland sites, especially in mountainous regions (Walker 1972, Smith and Eye 1986, Smith and others 1988). Less is known about hardwood growth and development on terrace sites. Terrace sites, often called second or even third bottoms, were former floodplains before the stream system moved to a lower elevation. These sites seldom flood, becoming inundated only in extremely high flood events. Therefore, terrace soils are usually well developed including argillic and fragipan horizons. Hodges (1997) stated that terrace sites can support hardwoods, but their growth and quality are generally not as good as active floodplain sites due to leaching of nutrients (and lack of nutrient recharge from flood events), development of pan horizons which restrict root development, and less favorable soil moisture relationships. Oftentimes terrace sites are bedded then converted to pine plantations. With the need for more information on hardwood management, particularly on terrace sites, a study was implemented to determine the growth and development of hardwood species on a terrace site using three different management objectives. Sixth-year results are reported.

MATERIALS AND METHODS

Study Site

The study site is located along Sandy Creek at the Idlewild Research Center, East Feliciana Parish, near Clinton, LA. Early 1940s photographs indicated the site was of old-field origin with scattered pine trees (Clifton 1987). The site also burned sometime prior to 1959 which resulted in a large number of multiple-stemmed hardwood trees due to resprouting.

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Table 1—Initial characteristics of major species in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana. Importance values are the sum of relative density and relative dominance (basal area)

Species	Trees per acre	Basal area (ft^2) per acre	Relative Density	Relative Dominance	Importance Value
sweetgum	19.54	5.27	12.80	6.48	19.28
loblolly pine	11.30	17.59	7.40	21.61	29.01
white oak	16.62	5.79	10.89	7.11	17.99
water oak	43.39	19.73	28.42	24.24	52.65
cherrybark oak	13.76	7.38	9.01	9.07	18.08
willow oak	34.02	20.17	22.28	24.78	47.07
other species[1]	14.06	5.47	9.20	6.71	15.92
Totals	152.69	81.40	100.00	100.00	200.00

[1] Other species include red maple, American hornbeam, pignut hickory, flowering dogwood, green ash, yellow-poplar, southern magnolia, crab apple, blackgum, sourwood, shortleaf pine, spruce pine, black cherry, southern red oak, swamp laurel oak, swamp chestnut oak, post oak, sassafras, horsesugar, winged elm, and American elm.

Four soil series were present on the study site (in order of magnitude): Calhoun silt loam, 65 percent (Typic Glossaqualf); Providence silt loam, 25 percent (Typic Fragiudalf); Bude silt loam, 5 percent (Glossaquic Fragiudalf); and Cascilla silt loam, 5 percent (Fluventic Dystrochrept). The first 3 soils were formed in loess or in a silty mantle, contained argillic horizons (2 had fragipan horizons), and were considered somewhat poorly drained to moderately well drained. The Cascilla silt loam was formed in silty alluvium, contained no pans, and was well drained.

Site index, base age 50 years, was estimated to be about 90 feet for cherrybark oak (*Quercus pagoda* Raf.), water oak (*Q. nigra* L.), and willow oak (*Q. phellos* L.) across the site, 115 feet for loblolly pine (*Pinus taeda* L.) on the Calhoun silt loam and 107 feet on the Providence silt loam. Average age for the oaks at the time of study installation was about 36 years with the scattered pine representing a second, older age class (Clifton 1987).

Study Design

In the Fall 1985, fourteen 2.541-acre (1-hectare) square plots were established in the stand. Each plot was surrounded by a 50-foot buffer strip. Species composition at the time of establishment was primary oak [importance value (sum of relative density and relative dominance) of 144; water, willow, white (*Q. alba* L.), cherrybark, swamp laurel (*Q. laurifolia* Michx.), swamp chestnut (*Q. michauxii* Nutt.), post (*Q. stellata* Wang.), and southern red (*Q. falcata* Michx.); table 1]. Other important species included sweetgum (importance value 19; *Liquidambar styraciflua* L.), and pines (importance value 31; shortleaf (*P. echinata* Mill.) and spruce (*P. glabra* Walt.) and loblolly).

Three treatments with 4 replications and a control with 2 replications were randomly assigned to these plots using a randomized incomplete block design (RIBD). These treatments are described below.

Timber—The timber treatment objective was to improve tree growth for timber production (veneer and sawlogs) by using a combination of crown thinning and improvement cutting to provide growing space for desirable trees (primarily red oaks). Trees marked for harvest were less-desirable species, suppressed, diseased, damaged, or otherwise poor candidates to remain until the next stand entry.

Wildlife Habitat—The wildlife habitat treatment objective was to improve wildlife habitat through a combination of crown thinning and improvement cutting to favor those tree species known to benefit wildlife populations regardless of tree quality relative to timber production. Mast-producing trees and cull and den trees were favored during marking. Also, one small opening, about 0.25 acre, was created in the plot center by severing all remaining trees $\leq$ 4 inches d.b.h. following harvesting of the overstory trees.

Timber/Wildlife Habitat—The third treatment involved combining the objectives of the first two treatments through a combination of crown thinning and improvement cutting for quality timber production and wildlife habitat. No small openings were made specific for the wildlife habitat objective aspect as in the wildlife habitat treatment.

All marking was done by developing tree class criteria (preferred stock, reserved stock, bolt stock, cutting stock, and culls; Putnam and others 1960, Dicke and others 1989) specific to each objective. Marking for the timber objective was conducted by a professional forester while marking for the wildlife habitat treatment was conducted by a professional wildlife biologist. These 2 individuals worked together to mark the combined timber/wildlife habitat treatment. Harvesting was conducted during late March to early June 1986 with a follow-up felling of all remaining marked trees.

Pre-harvest tree measurements were conducted during the Winter 1985/1986 and included species identification, d.b.h., crown class (Smith 1986), and tree class. Afterwards, all trees $\geq$ 4 inches were tagged at d.b.h. for future reference. Annual d.b.h. measurements were taken during the dormant season for the next 6 years. Trees that died each year were noted along with trees that grew into the 4-inch d.b.h. class ($\geq$ 3.6 inches).

Analyses involved using analysis-of-variance (ANOVA) in the RIBD. An alpha level of 0.10 was used to determine significance and Duncan's Multiple Range test was used to

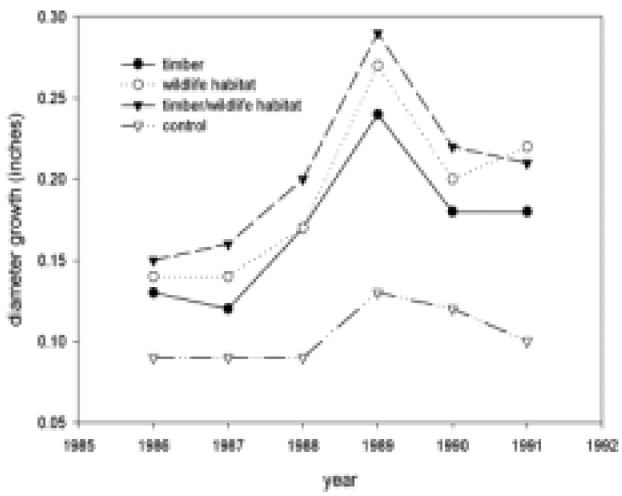

Figure 1—Annual diameter growth (inches) by management objective over a 6-year period following partial cutting in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana.

detect differences between treatments if the initial ANVOA was significant. Dependent variables tested included annual diameter and basal area growth, 6th-year diameter and basal area increment (referred to as cumulative growth), and stocking using Goelz (1995) stocking charts for bottomland hardwoods. These variables were tested for all trees combined, by crown class, and by 3 species groups (red oaks, white oaks, and pines). All measurements were taken in metric units then converted to English units for analyses and presentation. Scientific names follow Duncan and Duncan (1988).

Table 2—Cumulative diameter and basal area growth and changes in stocking over a 6-year period following partial cutting in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana.

Treatment	Diameter inches	Basal Area sq. ft./acre	Stocking percent
Timber	1.04a[1]	17.54	7.6a
Wildlife Habitat	1.16a	16.53	6.5a
Timber/Wildlife Habitat	1.25a	17.30	8.5a
Control	0.65b	15.22	-0.1b
p-values	.0128	.7139	.0367

[1] Means followed by different letters within a column are significantly different at p=0.10.

RESULTS AND DISCUSSION

Diameter Growth

Diameter growth averaged about 0.10-0.25 inches per year across the study site. In general, tree diameter growth in any given growing season was greater for the treated plots compared to the controls (figure 1). Exceptions included 1986 when only the timber/wildlife habitat treatment was greater than the controls, and 1987 and 1990 when both the wildlife habitat and timber/wildlife habitat treatments were greater than the controls. A general trend of increasing diameter growth occurred each year during the first 4 years following study installation (figure 1). This increasing response may reflect increasing crown area in the residual trees and thus increased photosynthate production and/or better climatic conditions.

Table 3—Cumulative diameter growth by crown class over a 6-year period following partial cutting in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana

Treatment	Crown Class dominant	codominant	intermediate	suppressed
timber	1.89a[1]	1.25a	0.72ab	0.53ab
wildlife habitat	1.71a	1.40a	0.76ab	0.82a
timber/wildlife habitat	1.81a	1.41a	0.93a	0.86a
control	1.36b	0.99b	0.47b	0.27b
p-values	.0373	.0305	0.586	.0237

[1] Means followed by different letters within a column are significantly different at p=0.10.

Table 4—Cumulative diameter growth (inches) by species group (see text for individual species within each species group) over a 6-year period following partial cutting in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana

	Species Group		
Treatment	red oaks	white oaks	pines
Timber	1.18a[1]	0.76ab	1.87a
Wildlife Habitat	1.23a	0.89ab	1.98a
Timber/Wildlife Habitat	1.34a	1.02a	1.91a
Control	0.82b	0.43b	1.41b
p-values	.0069	.1780	.1836

[1] Means followed by different letters within a column are significantly different at p=0.10.

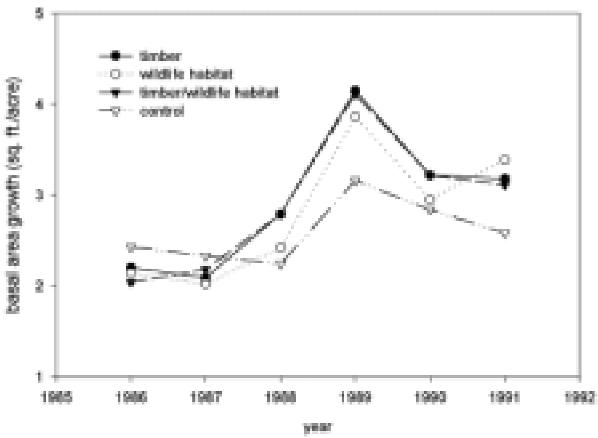

Figure 2—Annual basal area growth (square feet/acre) by management objective over a 6-year period following partial cutting in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana.

Cumulative diameter growth for all trees after 6 growing seasons was about 1-1.25 inches for the harvested treatments compared to only 0.65 inches for the controls (table 2). The cumulative diameter growth for the treated plots correspond to 1.75-2 inches of diameter growth over a 10-year period which is well below the 4-6 inches per decade considered indicative of a highly productive bottomland hardwood site (Briscoe 1955).

Cumulative diameter growth by crown class showed that dominant trees had greater growth compared to the codominant, intermediate, and overtopped crown classes (table 3). This was not unexpected given that dominant trees have larger, more healthy crowns compared to trees in the other crown classes. Codominant trees had the second largest cumulative diameter growth while no difference in cumulative diameter growth occurred between the intermediate and overtopped classes. As with cumulative diameter growth for all trees by treatment, growth was greater within a crown class for the treated plots compared

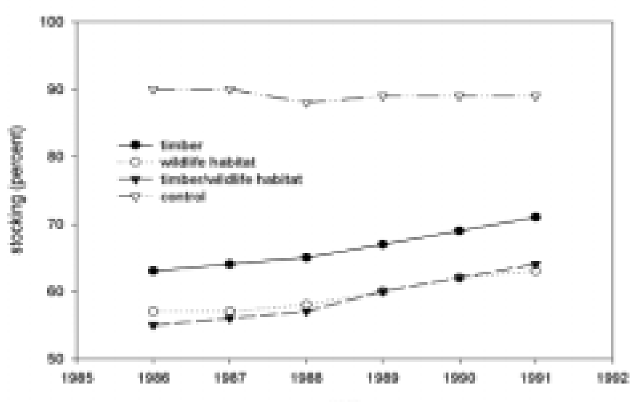

Figure 3—Changes in stocking (percent) by management objective over a 6-year period following partial cutting in an oak-sweetgum-pine stand, Idlewild Research Station, East Feliciana Parish, southeast Louisiana.

to the controls. Among species groups, the pines had greater cumulative diameter growth compared to the red oak and white oak groups with red oaks having greater growth than white oaks (table 4).

Basal Area Growth

Basal area growth averaged 2.78 square feet per acre per year between the partial cutting treatments and controls. Few differences occurred in basal area growth between the treatment and controls; exceptions being in 1988 when the timber and timber/wildlife habitat treatments had greater growth compared to the controls and 1991 when all 3 partial cutting treatments had growth greater than the controls (figure 2). No differences were found in the 6-year cumulative basal area growth between the treatments and the controls (table 2). No differences were also found in cumulative basal area growth between treatments and controls within each of the 4 crown classes or the 3 species groups. While treated plots had greater diameter growth, the control plots had a greater number of trees per acre to match the increases in basal area growth in the treated plots.

Stocking

Stocking was evaluated using Goelz (1995) stocking equation for southern bottomland hardwoods. Goelz (1995) noted that this equation was developed from Putnam and others (1960) table for stocking of an even-aged bottomland hardwood forest and not on long-term replicated research. Furthermore, since the present study was conducted on a well-developed terrace, and not on an active floodplain (Hodges 1997), applicability of Goelz's (1995) stocking equation to this type of site may be questionable.

Initial stocking in the control plots average 89 percent. Stocking for the treated plots was less because only post-harvest d.b.h. measurements, but pre-1986 growing season, were conducted (figure 3). Stocking remained about 89 percent for the control plots throughout the 6-year study period (figure 3). Changes in stocking for the treated plots showed a fairly consistent pattern with stocking in the timber objective treatment always being greater than in the wildlife habitat and timber/wildlife habitat treatments. This difference was due to the greater initial stocking in the timber objective treatment. No difference occurred in the change in stocking over the 6-year study period for the partial cutting treatments, averaging about 1-1.5 percent increase per year (table 2).

CONCLUSIONS

Several conclusions can be made based on the results from partial cutting in hardwoods growing on a terrace site.

First, hardwoods growing on a terrace site such as the one found on the Idlewild Research Center will respond to partial cutting, especially red oak species. One can expect about 2 inches of diameter growth per decade, 3 square feet of basal area growth per year, and about a 1 percent increase in stocking per year.

Second, pines, especially loblolly pine, grew better than hardwoods on the terrace site in this study. Intensive culture of pines, such as bedding and use of genetically-improved seedlings, would result in even better growth.

Third, few differences were found between the timber, wildlife habitat, and timber/wildlife habitat treatments, at least in terms of diameter and basal area growth. Assessments of log quality, financial returns, and specific wildlife habitat measures, such as mast production, quantity and quality of browse material, and vertical and horizontal structure, must be made before more definite comparisons can be made regarding treatment effects. The important point is to have specific management objectives stated before commencing silvicultural operations.

Finally, when determining management objectives, especially regarding decisions to convert terrace hardwoods to pines, keep in mind that hardwoods will grow on such sites, making mixed pine-hardwood management options viable. Furthermore, in afforesting pastures on terrace sites, planting pine and allowing hardwoods to develop underneath the pine following natural successional tendencies may constitute a viable "hardwood rehabilitation" option.

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