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Hardwood Regrowth and Yields on Bottomland Clay Soil Following Clearcutting

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SUMMARY

Five years of regrowth of a clearcut hardwood stand on the Delta Experimental Forest in Mississippi were evaluated to determine growth and development and biomass yields. Dry weight mean annual increments for years 1 through 5 following harvesting of an 11-year-old hardwood stand on Sharkey clay soil were 0.6, 1.9, 2.4, 3.5, and 3.2 tons per acre per year, respectively. Tallest trees cut during the 5 years averaged 8, 11, 13, 18, and 19 feet. Major species were green ash, Nuttall oak, American elm, sugarberry, water hickory, and roughleaf dogwood.

Additional keywords: Stand development, *Fraxinus pennsylvanica, Ulmus americana, Celtis laevigata, Quercus nuttallii, Carya aquatica, Cornus drummondii,* biomass, slackwater sites.

INTRODUCTION

While hardwood stands on clay soils may have site indices 20 to 40 feet lower at age 50 than stands on medium-textured soils, they are a significant part of the hardwood picture. Little information is available, however, on stand growth and development and biomass yields following clearcutting of young, even-aged stands on slackwater sites. This note presents information on stem numbers and development, together with aboveground biomass, after 5 years of regrowth following cutting of an 11-year-old stand on Sharkey clay soil. The 11-year-old stand—its biomass was measured at harvest (Krinard and Johnson 1981)—developed after logging of an approximately 70-year-old overstory, shearing of stumps and remaining stems, sweeping with a dozer blade, and sowing of Nuttall oak (*Quercus nuttallii* Palmer) acorns at 5- by 10-foot spacing. The stand is located on the Delta Experimental Forest, Washington County, MS.

METHODS

There were three replications of five regrowth periods that developed following the harvesting of the stand. Regrowth periods were from 1 to 5 years' duration. Also, plots that had been cut after years 1 through 4 were recut again after the fifth year. Total regrowth represented 5-year sums, as follows:

1st regrowth period	2nd regrowth period	Total regrowth
	years	
1	4	1 & 4
2	3	2 & 3
3	2	3 & 2
4	1	4 & 1
5	....	5

A randomized complete block design was used, with three blocks containing five treatments (or regrowth periods) each. The blocks consisted of three rows, with a middle measurement row and adjacent border rows, on 10-foot centers with 5-foot-wide mowed strips serving as middles between rows. Mowing was done yearly during the regrowth period. Within measurement rows, plots were 5 by 60 feet, with the interior 30 feet being measurement plots. Border rows were cut the same as adja-

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cent measurement rows. Per acre values presented for tree data are based on the 0.0034-acre measurement plots.

Prior to a cutting treatment, all stems >1.0 foot tall were tallied. Information taken included species, total height, and d.o.f. (diameter at 1-foot height). Stems were cut within 1 to 2 inches of the ground or stumps and weighed in the field on a digital balance. For each plot, a stem sample was taken for moisture determination. These samples were dried to constant weight in a kiln at 104°C.

Each year, for plots not scheduled for cutting, all sprouts occurring on the five largest stumps per plot (as determined after the 11-year-old stand was harvested) were measured.

During each growing season, five of the tallest stems per plot for each of 15 plots were measured biweekly for evaluation of stand development.

The Friedman test (at the 0.05 level) was used in analyzing the randomized complete block design for stem numbers and weights for the first and second regrowth periods and for total regrowth because of heterogeneity of variance resulting from variation in plot values. In addition to the Friedman test, a covariance analysis was used to compare volume mean annual increments and a partitioned polynomial was used to compare height growth of the tallest stems.

RESULTS

When the stand was cut at age 11, 21 different species were measured. Major species, based on the ratio of species volume to total volume (with volume equated to $\Sigma(\text{d.o.f.})^2{*}\text{height}$), were: ash (*Fraxinus pennsylvanica* Marsh.) (.34), Nuttall oak (.23), elm (*Ulmus americana* L.) (.12), sugarberry (*Celtis laevigata* Willd.) (.10), water hickory (*Carya aquatica* (Michx. f.) Nutt.) (.12), and roughleaf dogwood (*Cornus drummondii* C. A. Meyer) (.04). Major species for total regrowth were: ash (.47), Nuttall oak (.19), elm (.15), sugarberry (.04), water hickory (.05), and roughleaf dogwood (.06).

Number of stems varied greatly between plots at age 11 and for regrowth periods. However, mean stem numbers per acre at age 11 did not differ significantly by future treatments.

The trend, in number of sprouts per stump and total stems per acre >1.0 foot in height, was for the maximum number to develop in the growing season after cutting, then decline in succeeding years and again increase with recutting (table 1). An exception was that the first year's regrowth of treatment 1&4 had fewer stems than the second year's regrowth of treatment 2&3, but this

Table 1.—*Trees per acre >1.0 foot tall by treatment at age 11 and at recutting(s) with standard error, where SE = SD/$\sqrt{3}$*

Treatment	11 years	First recutting	Second recutting
	trees per acre		
1, 4	8,809 ± 1,680	35,816 ± 4,219	14,617 ± 2,443a[1]
2, 3	15,294 ± 2,674	44,334 ± 6,987	32,331 ± 7,374b
3, 2	13,939 ± 1,372	30,492 ± 1,844	35,622 ± 7,455b
4, 1	14,520 ± 3,186	25,749 ± 5,547	56,725 ± 10,352b
5	16,940 ± 1,721	24,974 ± 2,101	....

[1]Means appearing with same letter not significantly different within each column at 0.05 level by the Friedman test; if no letters, overall test was not significant.

appeared to be a chance occurrence as 1&4 had fewer stems than the other treatments both at age 11 and through two recuttings. Based on the five numbered stumps per plot, average sprout numbers per stump changed from 9.0 to 8.1, 5.9, 4.4, and 4.4 as the length of the regrowth period increased from 1 to 5 years. Through 5 years, 20 percent of the numbered stumps died.

Before harvest at age 11, the tallest tree was 29.5 feet (honeylocust (*Gleditsia triacanthos* L.)), and the largest d.o.f. was 5.4 inches (sugarberry). After 5 years of regrowth, an ash was the tallest tree at 19.8 feet and also had the largest d.o.f. of 3.3 inches (table 2). Fifty percent of the yearly height growth was attained before the end of May and more than 90 percent before the end of July. An analysis of variance of annual height growth of the tallest trees (using the 27 measurements with 1 year's regrowth, 21 with 2 years, 15 with 3 years, 9 with 4 years, and 3 with 5 years) showed a significant (0.05 level) linear trend of reduced growth with age. The quadratic and cubic trends were also significant. Mean height growth for years 1 to 5 following cutting was 5.8, 3.5, 2.5, 2.9, and 2.1 feet, respectively.

Basal area, based on d.o.f., averaged 108 ft^2 per acre for all 15 plots before the stand was cut at age 11. Total regrowth basal area for 5 years averaged 103 ft^2 per acre.

Because of plot variation, covariance analysis was used in analyzing both total recut $\Sigma(\text{d.o.f.})^2{*}h$ and recut $\Sigma(\text{d.o.f.})^2{*}h$ mean annual increments (m.a.i.'s) of 1 to 5 years, with the covariate being before cut $\Sigma(\text{d.o.f.})^2{*}h$. In neither case did the regression slope differ from zero, indicating original cut stem volume was not closely related to future stem volume production per unit area. Correlation coefficients were only 0.136 and 0.161, respectively.

Total recut dry weight yields per acre for treatments 4&1 and 5 were about 44 percent greater numerically

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Table 2.—*Average tallest tree and largest diameter at 1 foot above ground at age 11 and at recutting(s) with standard error, where SE = SD/√3*

Treatment	Height			Diameter at 1-foot		
	11 years	First recutting	Second recutting	11 years	First recutting	Second recutting
	feet			*inches*		
1, 4	23.7 ± 1.7	6.5 ± 1.0	16.1 ± 0.5	3.9 ± 0.7	0.8 ± 0.1	1.8 ± 0.2
2, 3	21.7 ± 3.2	9.8 ± 1.0	12.9 ± 1.0	3.2 ± 0.8	1.3 ± 0.1	1.5 ± 0.1
3, 2	24.8 ± 3.2	12.9 ± 0.4	10.7 ± 0.9	4.3 ± 0.9	1.7 ± 0.2	1.2 ± 0.1
4, 1	24.2 ± 2.8	17.9 ± 0.3	7.6 ± 0.2	3.3 ± 0.4	2.4 ± 0.2	0.8 ± 0.0
5	19.8 ± 0.3	19.3 ± 0.3	....	2.9 ± 0.4	2.7 ± 0.3	....
	22.8 ± 1.1			3.5 ± 0.3		

Table 3.—*Dry weight per acre mean annual increment by treatment at age 11 and at recutting(s) with standard error, where SE = SD/√3*

Treatment	11 years	First recutting	Second recutting	Total recutting
	pounds per acre per year			
1, 4	2,627 ± 344	1,261 ± 219a[1]	3,187 ± 313	2,802 ± 231a
2, 3	3,622 ± 796	3,822 ± 902b	4,917 ± 1,112	4,479 ± 896ab
3, 2	3,873 ± 979	4,816 ± 1,257b	4,028 ± 897	4,501 ± 1,093ab
4, 1	3,224 ± 519	7,006 ± 374c	4,425 ± 415	6,490 ± 378c
5	2,851 ± 140	6,427 ± 218bc	....	6,427 ± 218bc
	3,240 ± 269			

[1]Means appearing with same letter not significantly different within each column at 0.05 level by the Friedman test; if no letters, overall test was not significant.

than for treatments 2&3 and 3&2; the latter two treatments had total recut dry weight yields 60 percent greater numerically than treatment 1&4. However, only treatments 4&1 and 5 differed from treatment 1&4 at the 0.05 level.

Dry weight m.a.i.'s based on the first 1- to 5-year regrowth period differed significantly, while m.a.i.'s based on the second regrowth period of 1 to 4 years did not differ (table 3). Dry weight m.a.i.'s of 4 years' and 5 years' regrowth were greater than 11-year m.a.i.'s for the same plots. Other regrowth m.a.i.'s did not differ from corresponding 11-year m.a.i.'s.

The volume/weight of sprouts from the five largest stumps per plot proportional to total plot production was variable. Where all five numbered stumps per plot survived, their percentage contribution to total $\Sigma(\text{d.o.f.})^2{*}h$ averaged 47 percent and ranged from 16 to 66 percent.

Dry weight per acre prediction equations were developed for aboveground biomass using all 42 complete plot measurements (15 at age 11, 6 each for ages 1 through 4, and 3 for age 5) (table 4).

Table 4.—*Total dry weight per acre prediction equations with one and two independent variables*

Dry weight (lbs)/acre = $0.550245(Z)^{0.872025}$
in log units, $r^2 = 0.98$, percent standard error = 9.3%
in actual units, $r^2 = 0.95$, $S_{y \cdot x} = 3364$, $(S_{y \cdot x}/\bar{X})100 = 15.6\%$
Dry weight (lbs)/acre = $1.572968(Z)^{0.788033}\,10^{-1585.83(1/Z)}$
in log units, $R^2 = 0.99$, percent standard error = 8.3%
in actual units, $R^2 = 0.97$, $S_{y \cdot x} = 2771$, $(S_{y \cdot x}/\bar{X})100 = 12.9\%$

$Z = \Sigma(\text{d.o.f.})^2{*}h$/acre; percent standard error = $(10^{\sigma^2} - 1)^{1/2}100$.

CONCLUSIONS

This study was conducted in a young natural stand supplemented with acorn seeding that contained a mixture of species commonly found on slackwater sites in river bottoms of the South. For similar conditions, the following conclusions might be made:

(1) After clearcutting, the stand will regenerate to the same species via stump sprouts. Due to species differences in sprouting ability, some species will be better represented in the new stand than they were in the old.

(2) Of the common commercial species, green ash is the most consistent stump sprouter, and its sprouts are the best early growers.

(3) Sprouts of all species follow the same pattern of development: height growth will be most rapid the first year after cutting and then tends to decline to a 2- to 3-foot-a-year rate for ages 3 to 5. Tallest sprouts may grow to one-fourth the height of cut 11-year-old trees in 1 year and to two-thirds of that height in 5 years. Sprout growth each year is essentially complete by the end of July.

(4) Sowing acorns is a feasible method of establishing an oak component on slackwater sites following clearing, as nearly all the Nuttall oak trees in these study plots developed from handseeded acorns.

(5) Natural stand mean annual increment on bottomland clay soils is apparently maximized around 4 or 5 years or possibly a year or two later, but before 11 years.

(6) Potential yields from short rotation harvests of aboveground biomass may exceed 3 dry tons/acre/year, at least through one 4- or 5-year rotation. Whether this yield level can be sustained over several rotations is unknown. The yields do not differ much from those of far more intensively managed and expensive close-spaced sycamore plantations on better riverfront sites with medium-textured soils that produced 3-1/2 tons/acre/year over a first 4-year rotation and 3-1/4 tons over a second (Kennedy 1980).

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